THE

Railway Engineer,

AN ILLUSTRATED MONTHLY REVIEW

OF

THE CONSTRUCTION, MACHINERY, AND ADMINISTRATION OF RAILWAYS

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Contents.

Mr. Justice Lawrence has been appointed to succeed **Mr. Justice Bigham** as judge for England in the Railway and Canal Commission.

Col. Sir Donald Robertson and **Mr. A. V. D. Best** have been elected directors of the Southern Mahratta R.

The Rt. Hon. Lord Alverstone, G.C.M.G., Lord Chief Justice of England, has accepted the Presidency of the Railway Benevolent Institution for this year, and will take the chair at the annual dinner at the Whitehall Rooms of the Hotel Metropole on the 5th May.

Mr. Vincent Hill, general manager of the South Eastern and Chatham R., who has been so seriously ill for some time, is, we are glad to learn, convalescent, and hopes after a change on the Continent to resume his duties about the end of the month.

Mr. W. H. Waister, running superintendent, Great Western R., has had the 4th Class of the Order of the Red Eagle conferred upon him by the German Emperor. As Mr. Waister has had actual charge of the driving of more royal specials than any other living railway officer the distinction is well deserved. It is, however, almost, if not quite, an unique event for such an honour to be conferred on a representative of the locomotive department, the importance of which is evidently properly appreciated by the Kaiser.

Mr. J. A. Robinson, divisional locomotive superintendent at Wolverhampton, of the Great Western R., has been presented with a handsome silver salver by the L. and North Western R. Co. in recognition of the services rendered on the occasion of the accident at Shrewsbury on October 15th last.

Mr. H. K. Bamber has retired from the position of carriage and wagon superintendent of the East Indian R.

Mr. David F. Buttle, who was locomotive superintendent of the Great Southern R. of Spain, has been appointed locomotive, carriage, wagon and marine superintendent of the Antofagasta to Bolivia R.

Mr. O. H. Steele, of the Caledonian R., has been appointed assistant traffic manager of the Imperial Railways of China.

Mr. A. G. Crick has been appointed secretary of the Festiniog R.

Mr. T. O. Mein, assistant manager of the locomotive works of the Great Eastern R. at Stratford, was presented by Lord Claud Hamilton on the 18th ultimo with an illuminated Letter of Thanks (as under) on vellum from the Order of the Hospital of St. John of Jerusalem in England for the services which he has rendered to the Ambulance cause.

The Grand Priory of the Order of the Hospital of St. John of Jerusalem in England.

Extract from the minutes of a meeting of the Chapter General held on the 26th November, 1907, at St. John's Gate, Clerkenwell, London.

Resolved that the special thanks of His Royal Highness the Grand Prior and the Chapter General be hereby conveyed to Thomas Oswald Mein, of the Great Eastern Railway Centre, St. John Ambulance Association, for distinguished services rendered in furtherance of the work of the Order in connection with its Ambulance Department.

Dated this twenty-sixth day of November, One thousand nine hundred and seven.—George P., Grand Prior. Egerton of Tatton, Chancellor. Herbert Jekyll, Secretary-General.

Mr. Mein has been Hon. Sec. of the G.E.R. Ambulance Corps for 8 years, during which period the G.E.R. team has won the Inter-Railway Challenge Shield three times.

*

Stratfordians' Reunion Dinner.

THE fourth annual Reunion Dinner of the past and present staff of the locomotive department of the Great Eastern R. was held in the Abercorn Rooms of the Liverpool Street Hotel, London, on the 6th ultimo, under the presidency of Mr. W. D. Craig, late chief draughtsman, who was supported by a distinguished company of 80, including Mr. James Holden, Mr. S. Dewar Holden, Mr. A. J. Hill, Mr. F. V. Russell, Mr. J. H. Adams, Mr. W. Collingwood, Mr. G. Macallan, Mr. J. D. Twinberrow, Mr. G. Elliot, Mr. F. Dodd, Mr. J. G. Morley, Mr. S. Stone, Mr. J. H. B. Jenkins, Mr. F. D. Green, Mr. A. P. Parker and Mr. A. W. Polley.

Messrs. J. H. Adams, G. Macallan, A. W. Polley, W. Collingwood, A. J. Hill and A. Glaze contributed to the musical programme. Mr. F. G. Perry acted as accompanist.

The arrangements were made by a committee consisting of Messrs. J. Holden (chairman), Godfrey Elliot, A. J. Hill, J. W. Howard, W. F. Pettigrew, A. W. Polley (hon. sec.), and F. V. Russell.

*

Great Northern and Great Central Combination.

THE most important event of the last month in the railway world was the announcement of the agreement which had been arrived at (and which was unanimously approved by the shareholders of both companies on the 20th ultimo) by the Boards of the Great Northern and the Great Central railway companies to work the undertakings as one concern by means

of a Joint Committee for 999 years. The joint working begins on the 1st instant or so soon after as the approval of the Railway and Canal Commissioners is obtained. No Act of Parliament is necessary, as the agreement is made under powers conferred by the Gt. Northern and Manchester, Sheffield and Lincolnshire Rs. Act of 1858, which allowed 50 years for the formation of a joint working committee. The agreement covers all the railways of the two companies except the Lancashire, Derbyshire and E. Coast and Sheffield District and all lines which are jointly owned with other companies. The reason for these exclusions is obvious.

The first Joint Committee consists of the directors of the two companies. Lord Allerton is to be first chairman and Sir Alex. Henderson, Bart., deputy chairman. It is understood that Mr. Sam Fay will be the first general manager and Mr. O. Bury will go on the Board. Two other "principal officers" will not be taken over by the Committee; they have "considered the interests of the Great Northern R. Co. as "superior to their own personal interests."

The financial terms are: The Great Central takes £100,000 of the net revenue in respect of unfructified capital expenditure and then the balance is divided till and including 1910,—57 % to the G.N.R. Co. and 43 to the G.C.R. Co.; for 1911 and 1912 the division will be 56½ % and 43½, and subsequently 56 % and 44 %. The net revenue is arrived at after 3½ % has been allowed on duly authorised capital expenditure and £2,168,303 has been paid to the G.N. Co. and £1,635,029 to the G.C. Co.

There can be no doubt as to the savings which will be effected in almost every direction, and the public will be just as well if not better served.

One of the advantages which the Great Central R. will derive will be the use of the works at Doncaster. The Gorton Works, though they have been vastly improved since Mr. Robinson went there, are not sufficient for the requirements of the company, in addition to which wages are considerably less at Doncaster than at Gorton.

*

Economy of Mineral Oil for Hand-Lamps.

The economy to be effected by substituting Wright's patent mineral oil-burning hand-lamps for the old fashioned rape oil-burning lamps is being rapidly realised by railway companies at home and abroad. In the spring of last year Messrs. Wm. Sugg and Co, Ltd., had sent out about 2,000 of these lamps, but by November last there were considerably over 10,000 of them in constant use by guards, shunters, and road-van drivers, so that the experimental stage has evidently long since been passed.

We have made some enquiries, and find that the lamps are found to pay for themselves in about 12 months and roughly that every 1,000 lamps save between £500 and £600 per annum. As both Wright's lamps and rape oil burning lamps consume the same quantity of oil per hour, and as the cost of petroleum is about one-fourth that of rape-oil, it is not difficult to see the source of the economy. Another important feature of these new lamps is the ease with which the red and green glasses—if broken—can be renewed by the user without returning the lamp to the stores for the purpose. It may also be pointed out that the oil wasted is much less valuable and that the cleaning and trimming of lamps for mineral oil is effected in much less time than it is with those that burn rape oil.

Top Mast Motor Signal.

The General Railway Signal Co., of Rochester, N.Y., have just introduced a new motor signal in which the mechanism is placed at the signal arm itself, thereby rendering upright rods unnecessary.

Fig. 1 shows the signal and in fig. 2 is given a clearer view of the mechanism. The largest gear wheel *a* is concentric with the signal arm spindle and it is driven by the motor *b* through the smaller gear wheels. The slot mechanism is carried on a disc which is rigidly attached to the arm spindle. There is the usual engaging lever *c* which, when the armature d^2 of the compound lever *d* is attracted by the coils *e* e^2, extends into the path of the studs *f*. When, therefore, the motor is driven the slot mechanism is turned by the wheel *a*, providing, of course, that the magnet e^3 is energised.

Fig. 3.

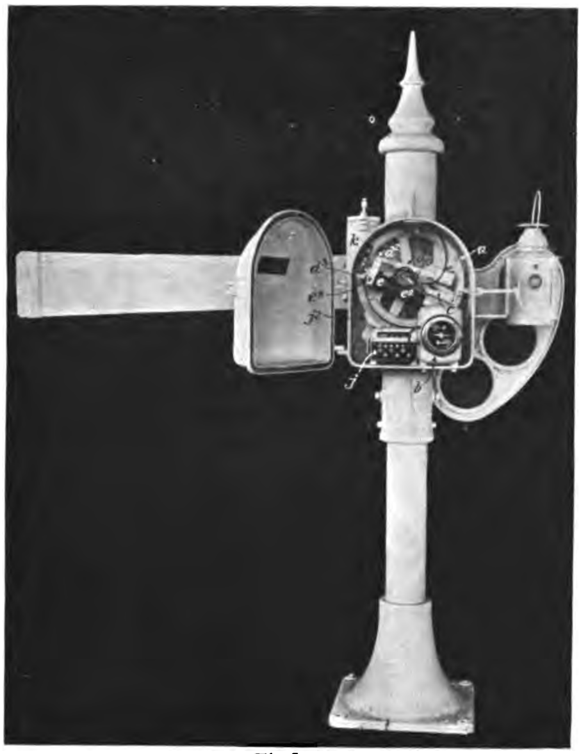


Fig. 1.

It will be seen that there are two pairs of coils. The smaller one, e, is called the "working coil." It is of very low resistance—less than ·1 of an ohm—and connected in series with the motor. Its object is to give more strength to the magnet whilst the signal is being operated. The larger coil, e^2, is termed the "retaining coil," and holds the signal in the "off" position. This coil can be of any resistance, but 800 ohms is recommended. When the mechanism is put together at the maker's factory it is so adjusted that the signal will be held "off" when the E.M.F. across the terminals of the retaining coil is 4 volts. The slot will release when the E.M.F. is reduced to 2 volts and the leverages are so proportioned that it will require a pull of about 4 pounds on the slot magnet to hold the arm "off."

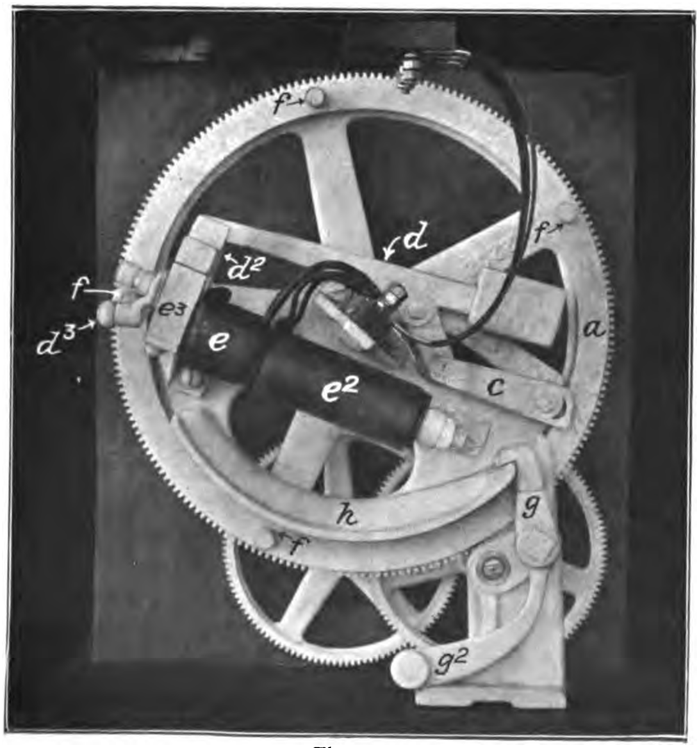


Fig. 2.

A novel feature has been introduced into this signal, which is the lock g which holds the rim h carried by the slot disc. It will be noticed from fig. 2 that the wheel a travels some distance before one of the studs f engages the lever c. This free movement allows the stud to turn the lock g and fill the rim h so that the arm may be lowered. The rim is so shaped that the lock is held away, but as soon as the slot is released and the arm goes to normal the weight g^2 restores the lock and the arm is again fastened.

Another novel feature is the operation of the contacts in the circuit breaker j. On the end of the compound lever d is a roller d^3 which, when the arm is just approaching the "clear" position engages the cam j^2 on the circuit breaker shaft and turns it. At the other end of the lever carrying the cam is a spring which reverses the shaft when the arm goes "on."

The dash-pot k is of the buffer type and a forged arm on the shaft of the slot mechanism comes against the stem of the dash-pot when the arm is 20 degress from its normal position.

Special care has been taken to make the apparatus accessible and so that it can readily be taken apart without special tools.

Fig. 3 shows the signal as installed as a "three-position" signal on the Great Northern R. of America.

The "Tudor" System of Electric Train Lighting.

The feature of this system is that it has no mechanically or electromagnetically actuated regulating apparatus, and the advantages claimed for it are briefly as follows:—1. Absolutely steady light. 2. Constant voltage. 3. Great simplicity. 4. Only one storage battery. 5. Long life or battery. 6. As the lamps cannot be overrun the bulbs are not prematurely darkened. 7. Reliability. 8. Good efficiency. 9. No slipping belt. 10. Low cost of maintenance.

The system is being introduced by the Tudor Accumulator Co., Ltd., 119, Victoria Street, Westminster, and is and has been for some time working successfully on several British and Colonial railways. It has also been adopted by the Prussian State Railways because of the simplicity of its regulating device.

A steady light is a matter of prime importance, but it is especially difficult to effect when the dynamo is driven from the axle of a railway carriage, because of the variable speeds at which the dynamo has to run, and because it is necessary to provide a storage battery to give light when the carriage is standing at stations or is stopped.

The voltage of a storage battery when charged rises considerably above its discharge voltage, which has to be high enough to maintain the required pressure at the lamps.

The difficulties of regulation are greatly increased by the fact that supervision during the lighting period is out of the question on account of the working conditions, and that delicate or complicated regulating apparatus is not reliable, as it is exposed to great changes of temperature, causing condensation of moisture, as well as to fine dust, soot, and continual vibration.

The trouble which railway companies have with their electrically lighted carriages is nearly always caused either by the

regulating apparatus or by the batteries, which generally receive very hard treatment. The dynamos proper seldom give trouble.

Fig. 1 shows the electrical connections of the "Tudor" system and fig. 2 the Wright dynamo, which is generally supplied with it. This latter is a shunt machine, which is provided with an extra regulating winding connected in series with the battery; this winding is not traversed by the whole dynamo current, as is usually the case with compounded machines, but by the battery current only, so that when the battery is discharging the current in the series winding strengthens, and when charging weakens the shunt field. The series winding is so arranged that the desired charging current, which can be varied at will by means of shunts, shall never be exceeded, no matter what the lamp load or speed of the train may be. This method enables dynamos to be designed with high efficiency and of small size for their output. The machines are provided with all the latest improvements, such as ball bearings, etc., and the commutation is excellent, so that the attention required by the bearings and brushes is reduced to a minimum. The dynamo is driven by a tight belt, but any other suitable positive drive may be used.

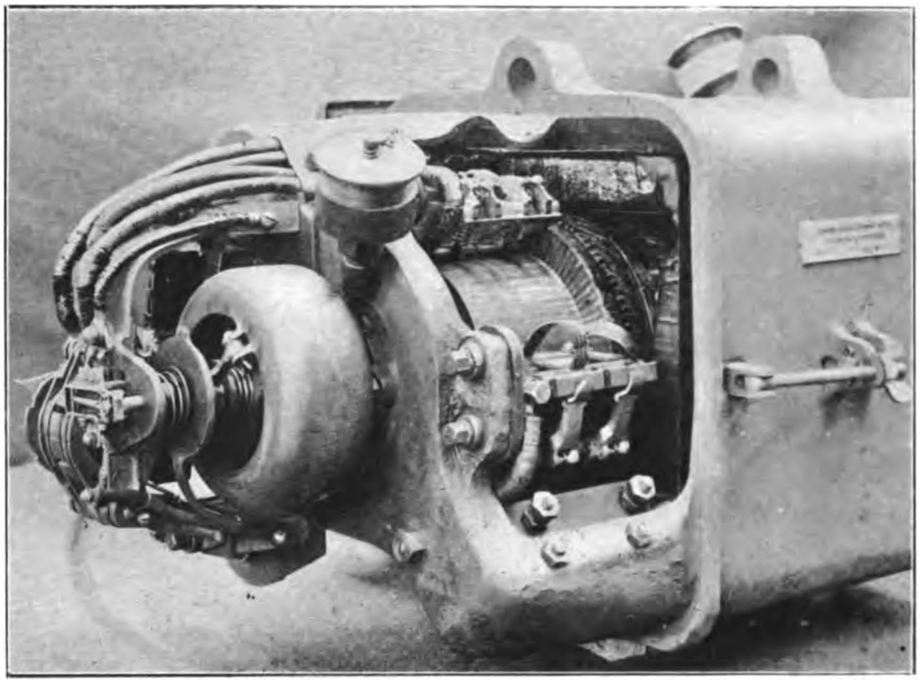


Fig. 2.

The dynamo is switched into circuit by means of a centrifugal governor which closes the switch of a solenoid which closes the field and armature switches; this method gives a quick make and brake of the main switches, and thus avoids damage to the contacts.

The whole switch gear is of the simplest description, and in practice has been found to give no trouble.

The regulation of the lamp voltage is effected by iron wire resistances which are placed in series with each lamp or group of lamps, and which entirely neutralise the variations of voltage which occur when a battery is sometimes charging and sometimes discharging. Fig. 3 illustrates one of these resistances together with its holder and cover.

In appearance these resistances resemble small glow lamps, but instead of a carbon filament the bulbs contain iron wire resistances in an atmosphere of hydrogen, which has proved to be the most suitable gas, on account of the high rate at which it diffuses heat. The resistances have an extremely high temperature coefficient; in fact, within certain ranges of temperature this coefficient is so high that their resistance varies almost proportionately to the potential difference across their terminals, and consequently the current

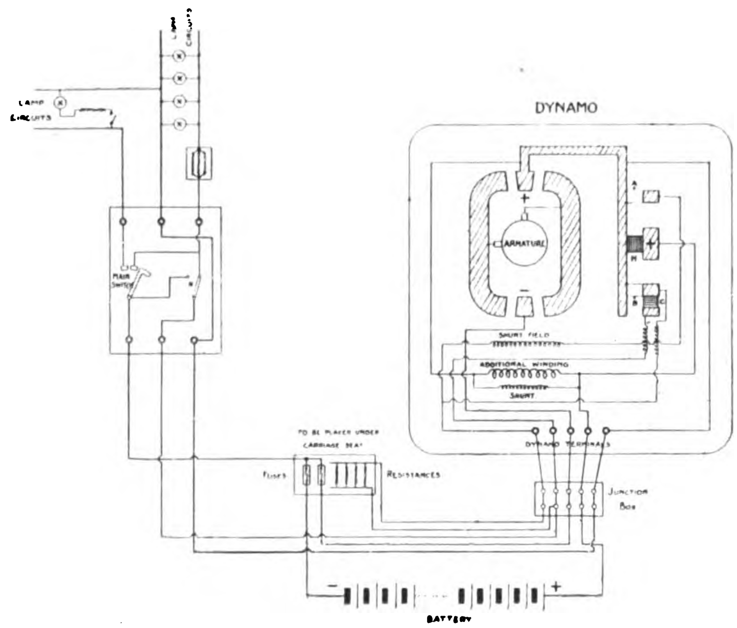


Fig. 1.

Cover.

Fig. 3.

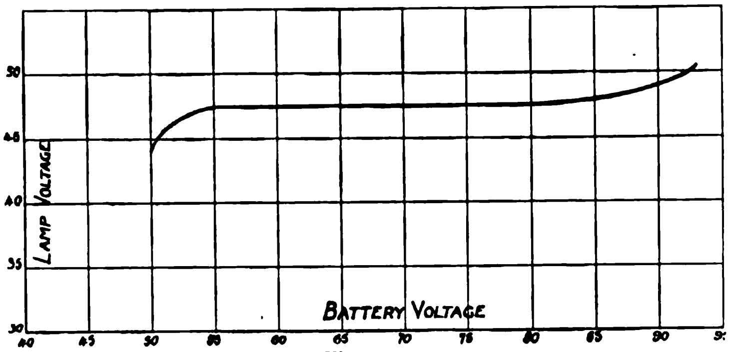


Fig. 4.

remains practically constant. This can be clearly seen from the following example :—Two 48 volt 16 c.p. lamps were connected in series with a regulating resistance; the voltage across the combination was then raised from 58 to 90 volts, when the lamp voltage rose from 47 to 49 volts. This regulation of pressure is within 2·1 per cent., and is much better than is usually obtained on good house lighting circuits.

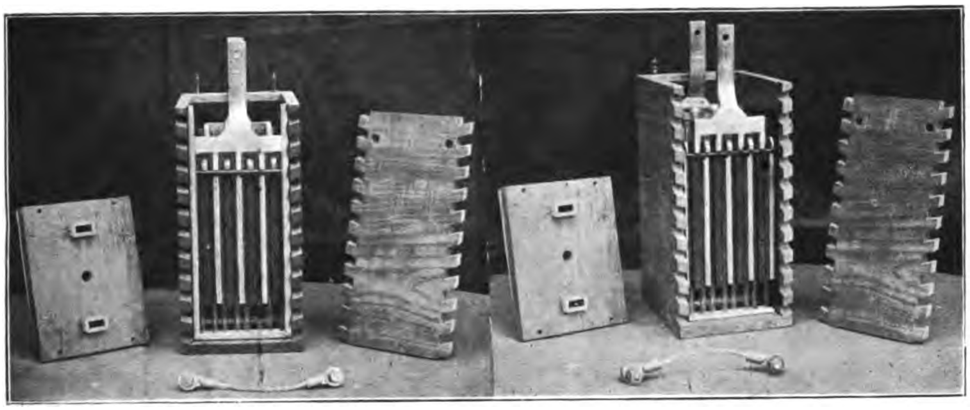


Fig. 5.

From the curve, fig. 4, it is easy to see that between 58 and 80 volts the lamp voltage was quite constant.

By the use of such resistances it is possible, without any other regulating device whatsoever, to charge the battery with the lamps across it during the lighting period.

The principal reason for the adoption of two batteries is that the regulating apparatus is thereby simplified, but on the other hand the cost of upkeep of double battery systems is materially increased, and it is advisable, if not necessary, to clean the batteries every ten to twelve months. With the "Tudor" system it is, we understand, only necessary to clean the batteries after they have been working for two or three years.

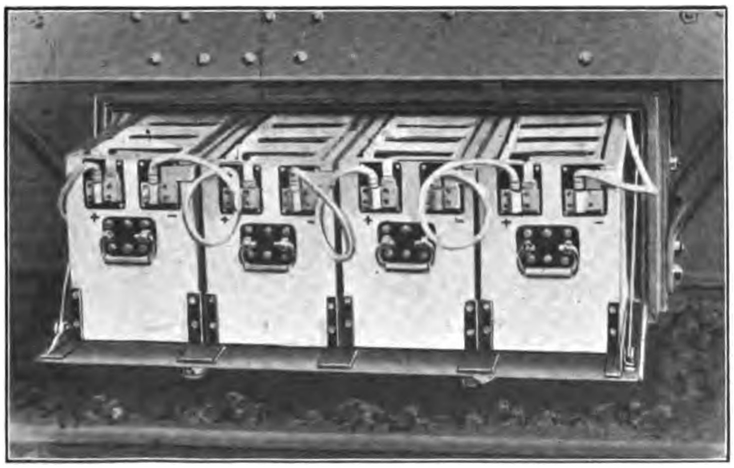


Fig. 6.

As in all electric train lighting systems, the upkeep of the batteries is by far the most important item; it is essential that they should be small and have a long life.

These conditions are best secured by charging during the lighting period (the dynamo being switched out when no lights are required), by so adjusting the charging current that the specific gravity of the electrolyte is the same at the end as at the beginning of the lighting period, and by the construction of the dynamo being such as to prevent the charging current exceeding a predetermined and adjustable limit.

The iron wire resistances can very conveniently be placed in some portion of the lamp fittings, or on circuits where all the lamps are served by one switch only they can be fixed in a small case or frame in series with the whole circuit; with this latter arrangement resistances of 2 and 2½ amperes may conveniently be used.

The Tudor Co. supply two distinct types of cells for train lighting. The first type, fig. 5, is similar to that in most general use on British railways, the plates being fitted in a lead-lined teak box which is provided with a lid held in position by screws, enough room being left above the plates to allow for a large quantity of acid. This construction has the advantage of obviating the necessity for constantly refilling; on the other hand inspection of the plates is difficult, as the lid has first to be removed. The cells are joined together by means of lead plated copper cables and bolts.

The second type, fig. 6, is more generally used on the Continent; the cells are in ebonite boxes, and 2, 3, or 4 cells, according to their size, are put into an outer wood box, which is lined on the inside with special acid proof material and is provided with handles for carrying.

The cells in each box are joined together by burned lead connections and are provided with loose lids.

This construction has the advantage that inspection of the plates is at all times possible, and consequently that it is easy to see if they tend to buckle or form short circuits, or if repairs are necessary. The specific gravity of the electrolyte can be easily observed, and the contacts cannot corrode, as lead is the only metal used above the cells.

Restaurant Car; Great Indian Peninsula Railway.

In our issue for October, 1905, we illustrated the new trains designed by Mr. A. M. Bell, carriage and wagon superintendent of the Great Indian Peninsula R., for the Poona express services, and we are now indebted to Mr. Bell for the annexed views of the interior and exterior of a restaurant car which he has recently designed and built at the company's works at Parel.

The car is 64ft. long over the vestibules and, like the Poona trains, 10ft. wide. This increased width which Mr. Bell has been able to introduce has enabled him to provide seating accommodation for 40 passengers with comfort and convenience.

panels the ninth and tenth were erected in part only, that is the top member of the panels were left off until the two bottom members of the central panels had met and been connected together (August, 1877).

It had been intended from the first, and was now found to be the case, that the arch should be built rather high, it being considered that whilst it would be almost impossible to raise the centre of the arch if it was found to be too low, yet that it would not be very difficult to lower the arch if it was too high. The actual amount that both sides of the arch were too high was 14 inches, and as the steel wire ropes supporting the structure had been purposely kept in position and taut by means of cast iron wedges, these wedges were now slackened with the aid of hydraulic jacks until the two ends of the arch were at the correct level, and the junction piece was now inserted, after some advantage had been taken of certain changes of temperature.

It was now felt that if there were any considerable changes of temperature now that the intrados was connected and the wire ropes were taut, that there might be some injurious stresses upon the permanent structure, and with this in view, and as soon as possible after the intrados had been connected, the sand boxes under the bearings of the horizontal girders over the piers next the arched opening were now brought into use, and the sand allowed to escape for a few minutes, thus lowering the top end of the ropes sufficiently to ease them of a portion of their load, but still leaving them taut enough not to allow too much stress to be thrown upon the junction piece lately inserted in the intrados of the arch.

After this it was a simple matter to complete the arch rib and to build upon the haunches the dwarf trestles and upon these and the arch to finish the top horizontal girder.

The lifting of each part of the arch into its place was performed by means of a pulley carriage which travelled upon a wire rope slung after the manner of a suspension bridge cable between temporary trestles placed over the piers next the large arched opening. The materials were brought in boats to underneath the bridge, and were lifted by means of a rope worked by a windlass fixed under the temporary trestles, and in the same position were the windlasses that hauled the pulley carriage to and fro along the wire suspension rope.

This single suspension cable was, however, found not to be exactly suitable for the lifting of the materials that were required near the crown of the arch, and which had to be deposited at some distance from the centre line of the bridge.

In this position a derrick had to be fixed, the hoisting rope for which was worked by a windlass fixed at the foot of the pier and near the springing of the arch. The derricks themselves were placed in position and removed by means of the wire suspension cable slung from the temporary trestles.

It was found rather difficult to secure the first, second and third panels of the arched rib during the progress of their erection, and it has since been considered that a flat or rigid bearing of suitable width would have been erected with greater ease than was the existing hinged bearing. Had this been done, possibly the arch could have been shallower at the crown and wider at the haunch than at the top, thus giving the greater weight of metal at the lower and more convenient level.

Garabit Viaduct.

This bridge carries the Marvejols-Neussargues line of the Orleans Railway Company across the valley of the Trueyere, and was erected in the years 1880-4.

The total length of the viaduct is 1,813ft., of which the iron portion is 1,470ft. in length, and the height of the two highest piers is 262ft., of which there is 59ft. of masonry and 203ft. of ironwork.

The arched ribs of the large span are of crescent shape, are pivoted at the abutments where they rest on the masonry, and the top is at an height of 420ft. above low water. A series of piers, some of which rest on the arch and others resting on masonry piers, carry the remainder of the spans, and this completes the structure.

The large arch is 514ft. 4ins. in span and has 213ft. 3ins. mean rise. The great height of this above the ground did not allow of the erection of the arch by means of staging and centreing.

After the completion of the piers the continuous girders on each side of the arch were rolled over the piers into their place, and whilst their forward ends projected over the piers a certain distance over the arched span the abutment ends were solidly anchored down to the masonry.

The ribs were built out from the springings, the first panel being put together on a staging which rested on the stonework, but was suspended from the projecting girders overhead. A couple of derricks were then placed upon the projecting end of the girder and by their assistance the next bay was erected. In this manner the arched ribs were built out from each springing, the point of attachment of the supporting cables being varied from time to time as the cantilever progressed further out.

The cables used in this temporary work had a breaking load of 80 tons, but in no case were stressed to more than 15 tons.

The time occupied in building the arch was from July, 1883, to April, 1884, and the weight of ironwork in the arch alone was 1,200 tons.

The Blaauw-Krantz Viaduct.

This bridge is situated in Cape Colony and carries the railway. The central arch is of 230ft. span. and 100ft. in height, and on each side of this are two double cantilevers, making altogether five spans, of a total length of 480ft.

The overhead cantilever girders were used as cranes for the erection of the lower parts of the arch, the remaining parts being erected by building out.

H. Miscellaneous.

New Kew Bridge.

Although this is not strictly an iron bridge, it may yet be taken as an interesting case of ironwork provided to carry temporary loads, and so not altogether out of the scope of these articles.

Eleven centres or plate girders were provided to carry the masonry of each arch (see fig. 25), and there are three arches (fig. 26) in the bridge. Each iron centre was delivered in five sections, and it was therefore necessary to make four joints on site. The ironwork was carried in the first instance on site on barges in the river below, and two of the joints, that is, those connecting the springing and the haunch section, were riveted up on the barge before they were placed in their position in the bridge.

These two haunch joints may therefore be taken as part of the rib and do not enter further into this consideration.

The remaining joints, that is those nearer the middle of

the span and within the trestles, were riveted up in situ after all the parts of the rib were fixed. Over the trestles, at *a a* in the figure, the ribs were carried at four points, the two springings of the arch and by the two sand boxes over the trestles.

The position of these two joints was carefully fixed to be at the points of contra-flexure of the ribs calculated as curved continuous girders, and if hinges instead of riveted joints

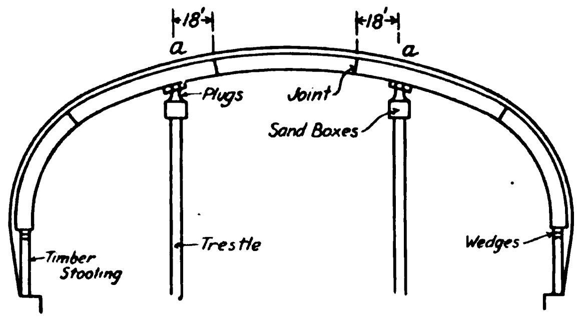


Fig. 25.

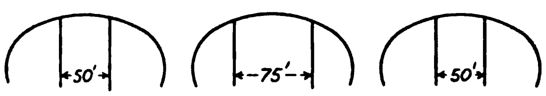


Fig. 26.

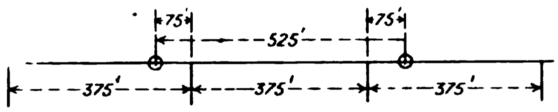


Fig. 27.

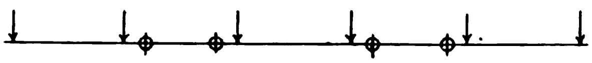


Fig. 28.

had been provided at these points the rib would have become a curved cantilever, which would have consisted of a pair of curved cantilevers from each springing to the hinge, and an independent girder supported at such points. The joints were, however, riveted up and the rib thus became a curved continuous structure supported at four points.

The sand boxes were partly provided for the purpose of striking the centres.

With reference to the use of the riveted joints or the hinged joints between the two timber trestles, two cases of other bridges were referred to in the descriptive article given in our contemporary *The Engineer*. The two cases referred to are instances in which a conversion from a continuous girder to a cantilever has actually been effected.

The first case is that of the Kentucky bridge, which is also referred to in this series of articles (No. VII., page 341) and shown in fig. 27. The bridge consisted, as originally built, of three spans each of 375ft., erected as continuous girders, but as it was feared that the two intermediate supports, being tall iron piers, would rise or fall under temperature influence more than the two rock abutments at each end, it was decided to cut the girders at the points of contra-flexure and convert the central length of girder into a girder of 375ft., with two cantilevers on each side of 75ft., thus making the length of the central portion 525ft. and the two outer lengths 300ft. only. Of course, this method of cutting the girders had been intended from the commencement of the work, and the girders were only made on the continuous girder principle for purposes of erection.

The other case referred to is that of a five span continuous girder bridge (fig. 28) over the river Cauche, at Etaples, near Boulogne. The girders were cut as shown in order to avoid the consequences of the unequal settlement of the four inner piers, and the second span was severed in two places, leaving the portion between the cut points as an independent and supported girder, hinged at its extremities to the cantilever arms of the first, third and fifth spans.

(To be continued.)

The Saltley Works of the Metropolitan Amalgamated Railway Carriage and Wagon Co., Ltd.

The principal works and headquarters of the Metropolitan Amalgamated Railway Carriage and Wagon Co., Ltd., are at Saltley, Birmingham, and the establishment is the largest and most completely equipped of its kind in Europe. Railway carriages and wagons of all descriptions are manufactured in these works for home and foreign railways, and a few illustrations of widely different varieties that have been recently constructed are annexed. Associated with the Saltley works are five other large establishments in which the construction of railway rolling stock and the manufacture of axles, iron and steel, plain and section, steel bars and plates, roofs, bridges, turntables, etc., is carried on.

The works at Saltley are conveniently situated, and the L. and North-Western R. leads directly into the yards. The works were established by the late Mr. Joseph Wright, originally a mail coach builder and contractor of London, and the area enclosed at that time was three acres. In 1859 the L. and North-Western R. Co. acquired the premises, and new works were built on adjacent land which formed the nucleus of the existing works there, after being carried on by the sons of Mr. Joseph Wright for many years, were finally acquired by the Metropolitan Railway Carriage and Wagon Co., Ltd. This concern and five others were amalgamated in the year 1902, since which year the works at Saltley have been almost entirely rebuilt and newly equipped with the best known up-to-date machinery and driving power. At the present time the total enclosed acreage is about 69 acres.

The principal offices are in a separate block of buildings facing a road belonging to the Company. On the ground floor are the Board Room and the offices of the managing directors, the secretary, the chiefs of departments, and their respective staffs. The drawing office and sun-printing department are on the upper floor. The office staff numbers 92 persons all told.

The shops are equipped with the most modern machines and appliances, especially designed to meet the quick-delivery methods of the present day. The smiths' shop, figs. 1 and 2, is 375ft. long by 200ft. wide. It is divided into four bays, of which the first two contain small steam hammers ranging from 5 to 12½ cwt., served by 112 smiths' forges. No. 3 bay is devoted to the production of drop forgings, and the duplication work, which is a feature of carriage and wagon building. This bay is equipped with 29 sets of Brett's steam worked drop stamps, ranging from 20 to 10 cwt., and 10 small steam hammers for

Fig. 1.—Smiths' Shop.

Fig. 2.—Smiths' Shop.

Fig. 3.—Underframe Shop.

Fig. 4.—Wagon Shop.

The Saltley Works of the Metropolitan Railway Carriage and Wagon Co., Ltd.

roughing out the work prior to stamping. In No. 4 bay are 10 furnaces, each having above it a Cornish boiler fired by the waste gases. These boilers are 20ft. long by 6ft. 6ins. diam., and the steam generated in them feeds the steam hammers, stamps, etc. This bay contains two 3-ton, three 30-cwt., one 25-cwt., and one 15-cwt. hammers, two 30-cwt. drop stamps, and a forging press of 1,200 tons capacity. There are also two 50-ton hydraulic forging presses, so that it will be seen that the smiths' department is fully equipped throughout. The department covers an area of 2½ acres, and includes a number of auxiliary shops, including hydraulic press shop, forge power house, diesinkers' shop, and iron racks.

Fig. 5.—Body Shop.

The hydraulic press shop is 190ft. long by 115ft. wide, in three bays. It is served by one overhead three-motor type 5-ton crane. There are 10 hydraulic presses, the smallest of which is for 50 tons and the largest for 500 tons work, also 16 smiths' fires and 5 coal-fired furnaces.

A 20 h.p. electric motor is employed in this shop for driving two hot saws, and there are two steam hammers and hydraulic presses combined for angle iron work. All hydraulic press work in connection with the building of underframes and bogies is done in this shop.

The forge power house contains in the boiler shed three hand-fired Lancashire boilers, each 30ft. long by 8ft. diam., two of these being fitted with Druitt Halpin's thermal storage system, Hopkinson's circulators, and Meldrum's furnaces. The three boilers are to be further equipped with McPhail and Simpson's superheaters. The power house contains two blowing engines of the vertical type coupled direct to Root's type blowers. There are two Weir pumps for maintaining the feed in the ten overhead boilers in the forge and the three in the boiler house, the former being fitted with the Metropolitan Amalgamated Co.'s own pattern of automatic feed valve, which is giving uniformly successful results.

The die-sinkers' shop is 100ft. square and contains a group of die-sinking machines driven by a 30 h.p. electric motor. All dies required for use in the Saltley works are made in this shop. The machines include two vertical milling machines, by Alfred Herbert, Ltd., a similar machine by Hulse and Co., of Manchester, a 10ft. by 4ft. 4ins. plane, and several other machines, all of which have been laid down this year.

In close proximity to the racks in which is stored a large assortment of bars, rods, plates, etc., are two shearing machines capable of cutting 4ins. by 4ins. bars while cold, and driven by an 18 h.p. electric motor.

The millwrights' shop is 150ft. long by 80ft. wide. It is devoted to general repair work, and a large staff of men are employed in repairing and re-fitting machine tools, engines, and other appliances with which the works are equipped. The machine and fitting shop is 470ft. long by 80ft. wide. The machines, which comprise among them a number of up-to-date and very fine tools, are grouped and driven by 9 motors having a total capacity of 220 h.p. With the exception of a few small American shaping machines, the whole of the tools are British made. High speed self-hardening tool steel is used throughout the shop, and all drilling is done through jigs and templates, which secures interchangeability and facilitates the erection of work sent abroad in sections. Among the machines may be mentioned a planer to take 14ft. by 4ft. by 4ft.; a stabbing machine with a 24ft. stroke; three 10-spindle drills; four heavy triple-geared lathes, by J. Butler, and Co., Halifax, specially employed for turning steel castings such as bogie centres and other work of a similar description; specially designed lathes for the turning buffers, and which turn both sides of a buffer head in one operation, the tool rest working in a former and the poppets being balanced so that they swing out of the way when it is desired to withdraw the buffer. In this shop also there are several machine tools specially designed for railway carriage and wagon building, as distinct from other work.

The desirability of re-building the machine shop on a large scale is a matter which is being considered by the directors, and if the scheme at present proposed is carried out the shop as re-constructed will measure 800ft. in length by 100ft. wide, and with it will be incorporated the existing millwrights' department.

The steel underframe shop, fig. 3, is 500ft. long by 200ft. wide. It is divided into four bays, each 50ft. wide, and served by five overhead 3-motor travelling cranes having a longitudinal speed of 350ft. per minute with a full load and a traverse speed of about 120ft. per minute. The cranes vary in lifting capacity, there being one of 10 tons, four of 5 tons each (all by Craven Bros., Manchester), and one (for feeding the machine) of 30 cwt., by Royce.

The work in this department is so organised that the raw material always enters at the north-west corner of the shop and is machined in the first bay. The bars are first passed through hydraulic straightening machines, the maximum capacity of which is 60 tons, whilst there are others of 40 tons and smaller capacities. They are then sawn off to the lengths required by cold saws, or milled and passed to machines

specially designed for sole bar drilling, and of which there are six, each 50ft. long, and provided with 6 movable heads; self-acting feeds and automatic knock-off gear and return. An electric motor of 10 h.p. is employed for driving these six machines. The machine for milling to shape the ends of sole

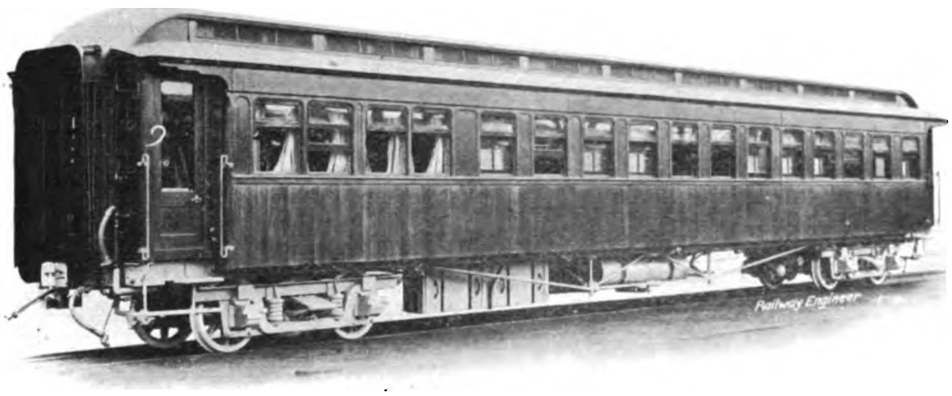


Fig. 6.—Lord Milner's Carriage.

bars, longitudinals, cross bars, etc., is 80ft. long. It will take 16 bars at once, of a maximum length of 70ft., and is driven by four directly geared 15 h.p. motors. The shearing machines will cut metal up to $1\frac{1}{4}$in. thick.

The installation of pneumatic drilling and rivetting machines, both fixed and portable, is very complete. The air for which is supplied from two compressors, each driven by a 55 h.p. motor. The compressed air pipes are carried all round the shop, along the girders and down each stanchion, so that the power is available in all parts of the building.

The two middle bays are fitted for hydraulic rivetting, the rivetters being carried in a special balanced jib crane designed and built at Saltley Works. There are 37 electric motors in

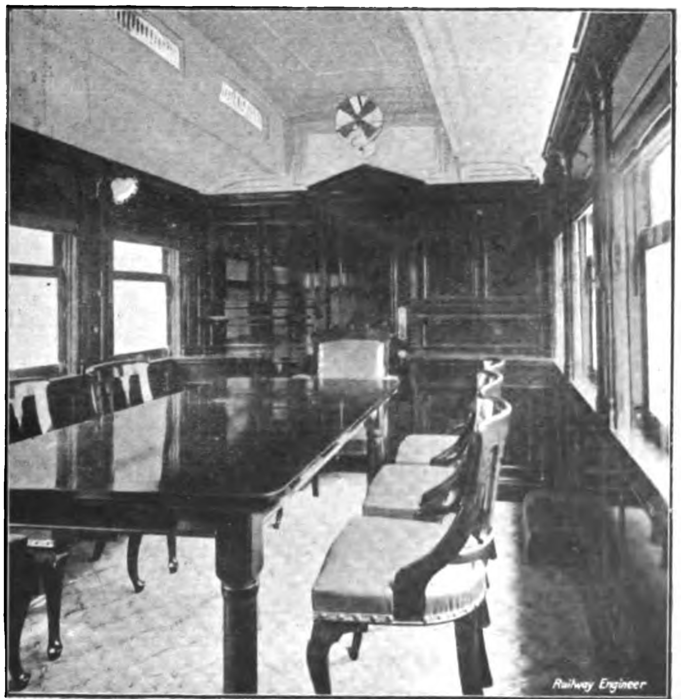


Fig. 7.—Interior of Lord Milner's Carriage

the steel underframe shop, developing a total of 454 h.p.

The foundry is 250ft. long by 50ft. wide. It contains two pneumatic moulding machines, one being specially designed for moulding deep axle boxes and the other is for general work. There are several hand-moulding machines in this department also. The foundry is served by two cupolas, and with only one of these in use the average output is 40 tons of finished castings per week. In close proximity are an axle box fitting shop, the pattern shop, the fettling shop and the brass shop.

The main electric power house adjoins the foundry. It is splendidly equipped with four 250 Kilowatt sets of Belliss and Morcom's triple expansion high-speed vertical engines coupled direct to General Electric Company's generators wound for 230 volts continuous current and one 60 Kilowatt set Bellis and Morcom's engine coupled to a Silvertown generator wound for 230 volts.

In the power house, but at a lower level, are two sets of condensing plant, one by Messrs. Allen and Co., of Bedford, and the other by Worthington's. The Allen set is capable of

Fig. 8.—Great Western and Metropolitan Railways Composite Carriage.

dealing with 30,000 lbs. of steam per hour. There is also on this floor a Shand Mason fire pump, the output of which is 1,450 gallons of water per hour at 120 lbs. pressure. In front of the power house is an artesian well 300ft. deep. This has a capacity of 10,000 gallons of water per hour.

The switchboard was supplied by the Silvertown India Rubber, Gutta Percha and Telegraph Co., Ltd. It extends across the full width of the power house and is made of black polished slate.

The boiler house alongside the power station contains three Lancashire boilers, each 30ft. by 8ft., and two Babcock and Willcox water tube boilers, with specially designed furnaces for burning wood refuse. There is one independently-fired superheater and two Green's economisers. The stack is 160ft. high, with an internal diameter of 8ft.

The saw mill is a very fine shop completed only two years ago, but such has been the growth of the business that it is already inadequate for its purpose, and plans have been prepared for its construction with a capacity 50 per cent. greater than that at present afforded. The existing dimensions are 400ft long by 150ft. wide, and in addition to this there is the "breaking down" mill, 75ft. wide by 175ft. long.

The saw mill is in three bays, each 50ft. wide, and the shop is served by one 5-ton 3-motor type overhead crane and one hand power crane of 30 cwt. capacity.

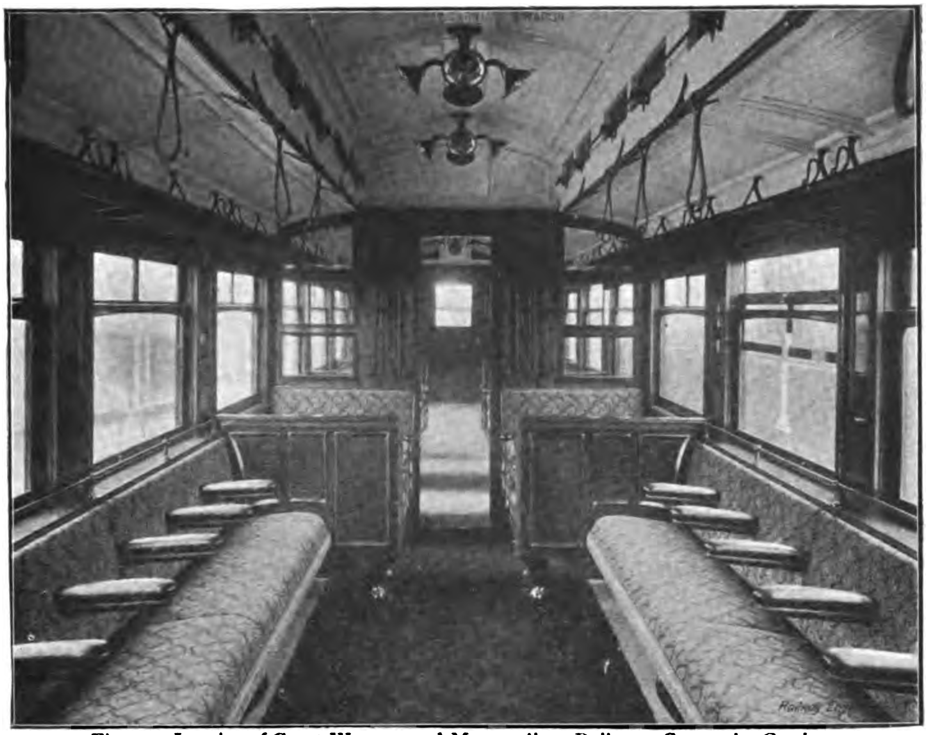


Fig. 9.—Interior of Great Western and Metropolitan Railways Composite Carriage.

The whole of the belting, motors and shafting are fixed underneath the floor, and the Company is about to put down a saw-dust and shaving extracting installation. The largest machine in the saw mill is a horizontal log hand saw, electrically driven and capable of taking logs 70ft. long by 4ft. square. There are also two high-speed planing machines for finishing match boarding at a rate of 100ft. a minute. The largest planing machine takes timber measuring 16ins. by 7ins.

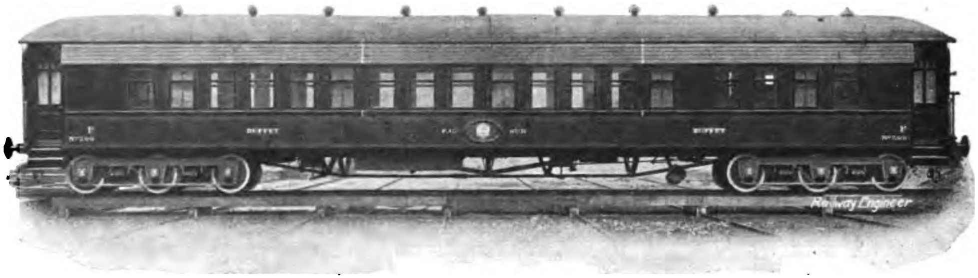


Fig. 10.—Restaurant Car; Buenos Ayres Great Southern R.

Fig. 11.—Interior of Restaurant Car; Buenos Ayres, Great Southern R.

The timber drying sheds cover a floor space of 71,200 sq. ft. for natural drying, and in addition there is a store of 5,000 cubic ft. capacity wherein timber is artificially dried, the temperature being raised to 130° F., and the heat and dryness of the air regulated by valves worked from the front of the building.

Adjoining the saw mills is the finishing department, measuring 400ft. long by 50ft. wide in one span.

This is equipped with a special sand-papering machine of a type designed at Saltley and patented by the Metropolitan Amalgamated Company, and a variety of special machines adapted for carrying out the various processes. Immediately adjoining this is the packing shop for ironwork, where a 5-motor electric crane is kept constantly employed.

The wagon shop is situated on the extreme east side of the Works' ground, and is one of the finest of the buildings. It is 800ft. long and is arranged in two bays, each 50ft. wide, served by three 5-ton cranes of the three-motor type. In this shop the work of building wooden wagons, also the large bogie type of wagons and standard types, is carried on. Fig. 4 is an excellent view of the shop.

The whole of the works is served by an overhead gantry, 50ft. high, with a span of 50ft. and a length of 800ft., the gantry being provided with two 3-motor type cranes of 5 tons lifting capacity each.

The body (fig. 5) and paint shops are separated from the other buildings. They are together 370ft. long by 260ft. wide. The body portions of the cars are built here and the trimmers' work is done in the gallery at the west end of the shop. The paint shop is for coaches only, and there is a polishing gallery corresponding to that in which the trimmers are accommodated in the body shop. The paint stores are completely equipped with grinding mills and other necessary appliances, occupies a separate building near by. The car and paint shop is served by 50 electrically-driven traversers.

A tramway on the 15ins. gauge is laid throughout the works, and telephonic communication between all departments

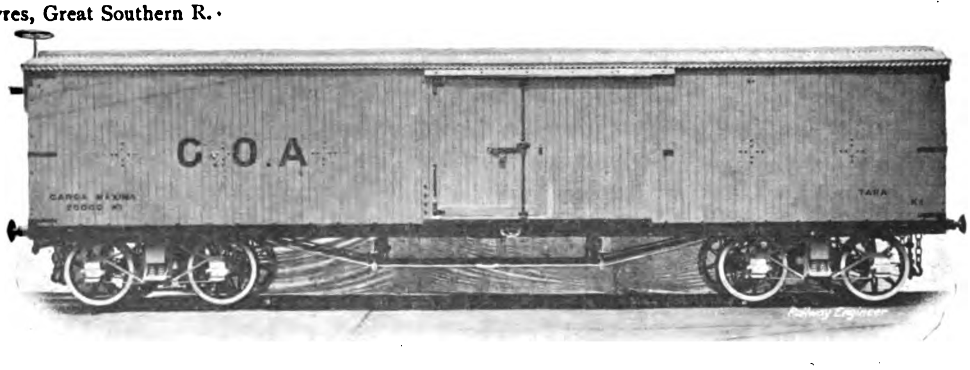


Fig. 12.—Covered Goods Wagon; Argentine Great Western R.

Fig. 13.—Cattle Wagon ; Argentine Great Western Railway.

is installed. There are 37 hydrants, all connected with the Metropolitan Amalgamated Co.'s own main, and firemen are on duty day and night. An efficient fire brigade manned by employees is maintained. The workshops and yards are lighted throughout by electricity, over 600 arc lamps being installed, besides some 10,000 incandescent lights.

As a general rule the boilers are under steam incessantly, except, of course, when shut down for washing out or repairs, and the bulk of the machinery is working continuously, the men being divided into day and night shifts. The whole of the wood working and paint shops are equipped with Grinnell sprinklers. The average number of men employed in Saltley Works averages 2,121, but at times a considerably larger number are engaged. Mess rooms are provided for the use of the staff and workmen. Those for the men are about to be re-built on an enlarged scale, with club rooms, shooting ranges and other devices for the social advancement of the employees.

The total horse power developed by the 147 electric motors installed in the works is 1,937 h.p., and in addition to the 15ins. gauge tramway there are 5·8 miles of sidings on the standard 4ft. 8½ins. gauge in the yards.

Having thus briefly described the principal features of the shops comprising the works of the Metropolitan Amalgamated Railway Carriage and Wagon Co., Ltd., attention may be drawn to a few selected examples of the rolling stock recently built there.

Considerations of space prevent the writer from going into a detailed description of each of the types illustrated. Figs. 6 and 7 show special car built for the use of the late High Commissioner in South Africa, Lord Milner, and is a most luxuriantly appointed vehicle running upon two four-wheeled bogies and comprising several distinct compartments, each having its separate purpose. The car is built for the 3ft. 6ins. gauge.

Other rolling stock illustrated (figs. 8-13) includes a composite bogie coach for the Great Western and Metropolitan joint electric service between Hammersmith and the City, a restaurant car for the Buenos Ayres Great Southern R., and two bogie wagons for the Argentine Great Western R.

In conclusion, the writer's thanks are due to the directors of the Metropolitan Amalgamated Railway Carriage and Wagon Co., Ltd., for permission to inspect the works at Saltley.

Valve Gears of Locomotives.*

As this Association was favoured at its last convention with admirable mathematic analysis of various forms of valve gear in use on locomotives, it is evident, from the wording of the subject assigned to this committee, that it is desired to present the practical considerations governing present-day locomotive engineering in regard to choice and design of valve gears and the results obtained in general practice and use. The subject is, perhaps, the least understood of all the detail mechanism of the locomotive, and while most railroad and drawing offices can produce men competent to lay out and design the ordinary type of motion, yet the builders are very generally called upon to furnish the design, subject possibly to a specification that allows and expects the builder to use his best judgment in regard to these important details. That his confidence is not misplaced is to be seen daily in the fine performance of engines the country over, in all classes of service, fast and slow, passenger, freight, work and switching.

The Stephenson link motion has held its own in this country, almost without consideration being given to other types, until very recent years. The types and weights of engines employed lent themselves to convenient use of this type of link motion, which has many desirable and valuable features to commend it.

The time came, however, when it became expedient to make changes for some of the following reasons : Some types of engines have so many wheels, or they are so closely grouped that it is a difficult matter for enginemen to get under them except when over a pit. This contributes to neglect, lack of prompt adjustments for wear, lack of proper inspection, and a more rapid deterioration. With the increase in size and weight, the dimensions of eccentrics required for large axles are excessive and their peripheral speed is so great as to make maintenance and lubrication of the eccentrics and straps expensive and troublesome.

By the abolition of eccentrics and straps, a long list of engine failures is eliminated; expense for maintenance and lubrication reduced; room gained for better cross-bracing and strengthening of frames and adding to convenience on account of the men not being required to go under the engines to the same extent. On heavy engines, the weight of all moving parts of a link motion, from the eccentric straps through to the valves, is so great as to contribute to accident and rapid wear, so that an equally efficient valve motion with lighter parts and greater accessibility is in demand for heavy power.

For many reasons, we cannot lower the standard of efficiency as set by the Stephenson link motion. Economy in use of coal and water are more necessary than a reduction in weight and wear of valve motion parts. No railway manager will sanction the use of a device, no matter how beautifully simple it may be, if his costs as measured in coal are increased thereby. Fortunately, we are able to

*Report of the Committee—Messrs. C. A. Seley (chairman), R. Quayle, L. H. Turner, and J. H. Manning—to the American Master Mechanics' Association.

obtain a valve motion having the desirable features of lighter parts and accessibility without a loss of efficiency in the Walschaert motion, which has come into extensive use the last few years.

At this point in the report valve motion diagrams were introduced, made by a special machine devised by the Baldwin Locomotive Works. These clearly showed that, notwithstanding the constant lead of the Walschaert motion, the pre-admission is more favourable at short cut-offs than with the Stephenson motion. This data also showed that the various points of pre-admission, port openings, equalisation of cut-offs, release and the closures can be as favourably arranged with Walschaert motion as with the link motion examples presented.

The following table of weights are given us for a 22-inch consolidation engine, said to be identical in everything except the valve motion, built by the Baldwin Locomotive Works:

	Complete.		Moving Parts Only.	
	Stephenson.	Walschaert.	Stephenson.	Walschaert.
Crossheads	676	746	676	746
Guide bearer	814	1,116	—	—
Guides	1,712	1,712	—	—
Eccentrics	600	—	600	—
Crank arms	—	250	—	250
Eccentric straps ...	1,100	—	1,100	—
Main crank pins ...	520	516	520	516
Links	238	418	238	413
Reverse shaft	325	655	325	655
Rockers and boxes .	618	730	618	730
Rocker rods and hangers	169	—	169	—
Link bearing	—	234	—	—
Eccentric rods	184	264	184	264
Valve rods	220	546	220	561
Valve yokes	154	140	154	140
Valve rod guide ...	24	28	—	—
Complete set ...	7,354	8,321	4,804	4,265

These figures indicate that while the valve gear on the engine with the Walschaert motion weighed 1,000 pounds more, yet the weight of the moving parts was less. The *American Engineer and Railroad Journal* of June, 1905, published some figures showing saving of weight by the use of Walschaert motion on L. S. & M. S. engines, as follows: 1,283 pounds on a consolidation, 1,215 pounds and 1,745 pounds respectively on two classes of Prairie type engines. These figures indicate a larger saving than the foregoing example, but it is possible that as these were early developments they may not be representative of present successful practice. It is a fact that similar valve motion ports on engines abroad are very much lighter than we dare use in our own practice. It seems fair to conclude, therefore, that we may yet look for improvement in this respect.

The matter of lead has received much attention, particularly with link motion, but, as a matter of fact, the measured full gear lead is only used possibly for a few turns of the wheels in starting the engine, and when running notches are in use the lead is entirely different, the amount being dependent upon various conditions. As the running notch leads for best results are within narrow limits, it is apparent that the full gear leads vary within a wide range. The amount of full gear lead is therefore of little importance in the operation of the engine if the running notch lead is right. If these premises are correct, there can be no argument as against the constant lead characteristics of the Walschaert motion, provided the lead is the proper amount for the running notches. The valve motion diagrams show that all the other events as derived by a link motion can be duplicated by the Walschaert motion so that, except in so far as the lead is concerned, equivalent operation can be obtained; hence, equivalent economies.

The practical operation of Walschaert motion is best shown by the testimony of roads using it in considerable numbers, and at a recent meeting of motive power officers and locomotive builders, held to discuss the results of the use of Walschaert motion engines, the roads represented having about 1,000 such engines, it was the unanimous opinion that Walschaert motion was equally well adapted to fast and slow passenger and freight service; that equivalent economies in fuel and water were obtained; that no reductions of tonnage ratings were necessary; that expense of maintenance and repairs were reduced; that inspection and repairs were facilitated; that construction advantages in the way of frame-cross bracing etc., were increased; that valve adjustments made are maintained and engines kept square much longer on account of the motion being more direct, rigid and positive for the passage of the valve-driving stresses; and that convenience of the enginemen, inspectors and shop men is promoted by the accessibility of the motion.

The discussion thus far has been with reference to the valve actuating mechanism proper, as ordinarily used on locomotives for operating the usual types of slide or piston valves. There are available for the use of railroads some patented forms of valve motion or systems or steam distribution which are claimed to obtain economies superior to those of the types already mentioned.

The Young valve gear has been applied to engines with Stephenson link and later a Walschaert motion having some detail modifications from the regular design has been proposed. The motion acts upon a wrist plate which has connections to two semi-rotary valves, and the effect of the combination produces valve events remarkable on account of absence of pre-admission, small amount of lead, quick port opening, large exhaust area and fine equalisation of the events. It is claimed, due to these features, that fine performance and superior economies are obtained which more than compensate for the cost of maintenance of additional parts required.

For the past six years the Allfree-Hubbell designs for improving steam distribution have been under test and the designers have made changes from time to time. The first design or "geared system," as the designers called it, has been superseded by what is known as their "compression system," some of which have been in service for several months. This design is supposed to embrace the economic features of the original design with some additions, and, as it now stands, it attempts to produce the following results: late release, late compression, low clearance, balanced compression, reduced cylinder radiation, quick admission and quick release. In the later design an auxiliary valve has been introduced for the control of compression alone, and allows the main valves to be made and set for a desired release with the Stephenson link, Walschaert, or any other motion, all the changes being made in the cylinders and valve alone.

This device has been under test on several roads and from an average of several reports it seems to give about 6 per cent. reduction in fuel consumption and 5 or 6 per cent. increase in train load, and is able to maintain the same or a little more speed than engines of the same size and ordinary design, except the cylinders. There is also a lighter drain on the boiler for steam, but we are unable to express the amount in figures. In making a study of this system for causes of the results claimed, we find a very late compression, which, according to the argument of the designers, means that the negative working pressure is acting at a time when it produces the least effect on crank pin. In other words, when the crank pin is very near the centre, from this point alone, an increased load is possible, not so much from an increased working pressure as from a reduced negative work. In view of the above argument any given load could be handled with a less amount of steam, which means a less amount of coal and therefore brings the handling of greater load within the possibilities of the boiler. In addition to this, the reduced clearance is claimed to be responsible for a considerable steam economy.

Siemens Bros.' "All-Electric" Signalling and Interlocking at Snow Hill, Birmingham; Great Western Railway.

In the *Railway Engineer* for November last there was published a description of the new all-electric signal system designed by Mr. Ferreira and brought out by Siemens Bros. and therefore the arrangements are somewhat tentative and the numbers of the levers shown are not necessarily those that will be employed.

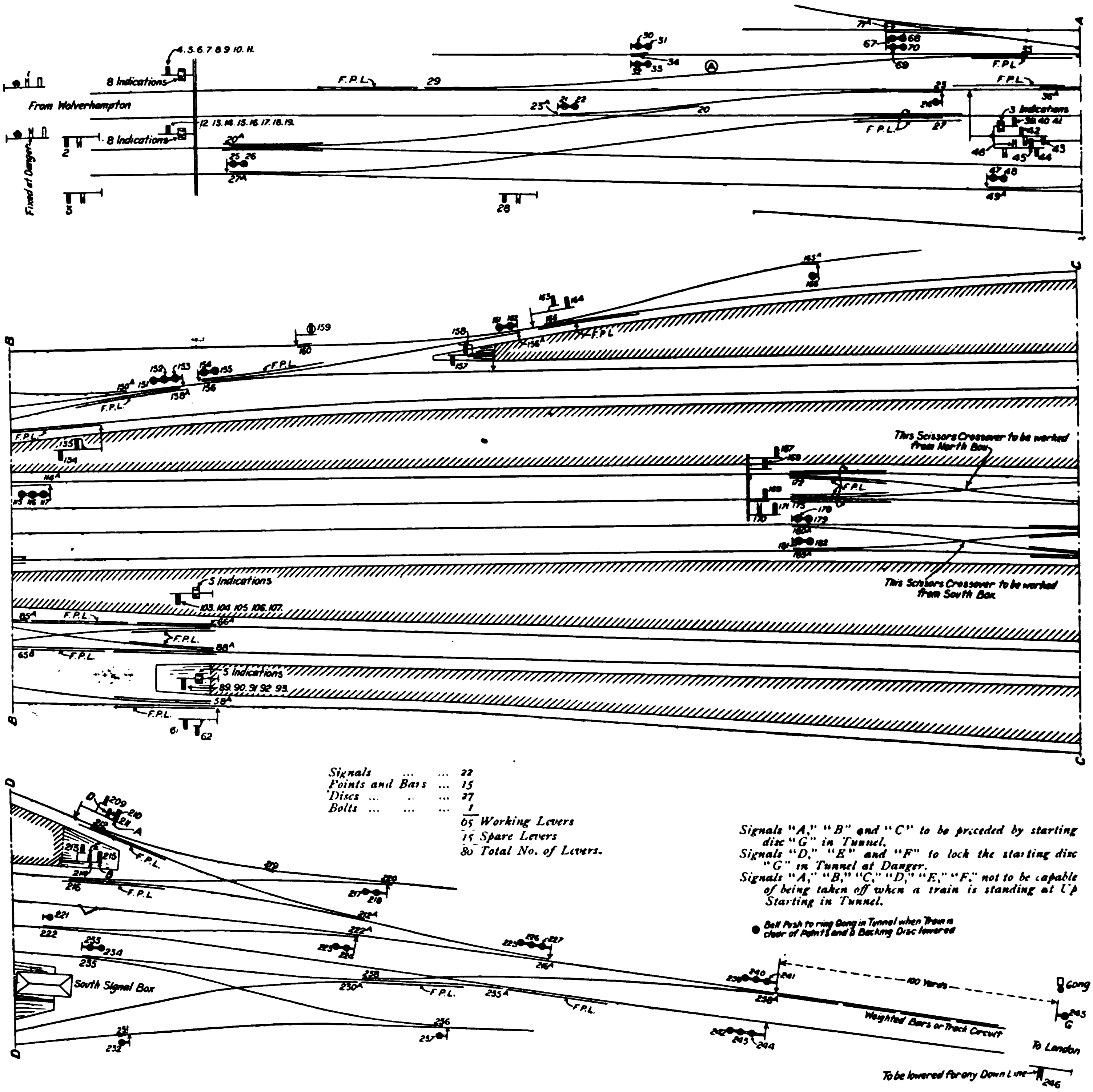


Fig. 1.—Siemens Bros.' "All-Electric" Signalling and Interlocking at Snow Hill, Birmingham; Great Western Railway.

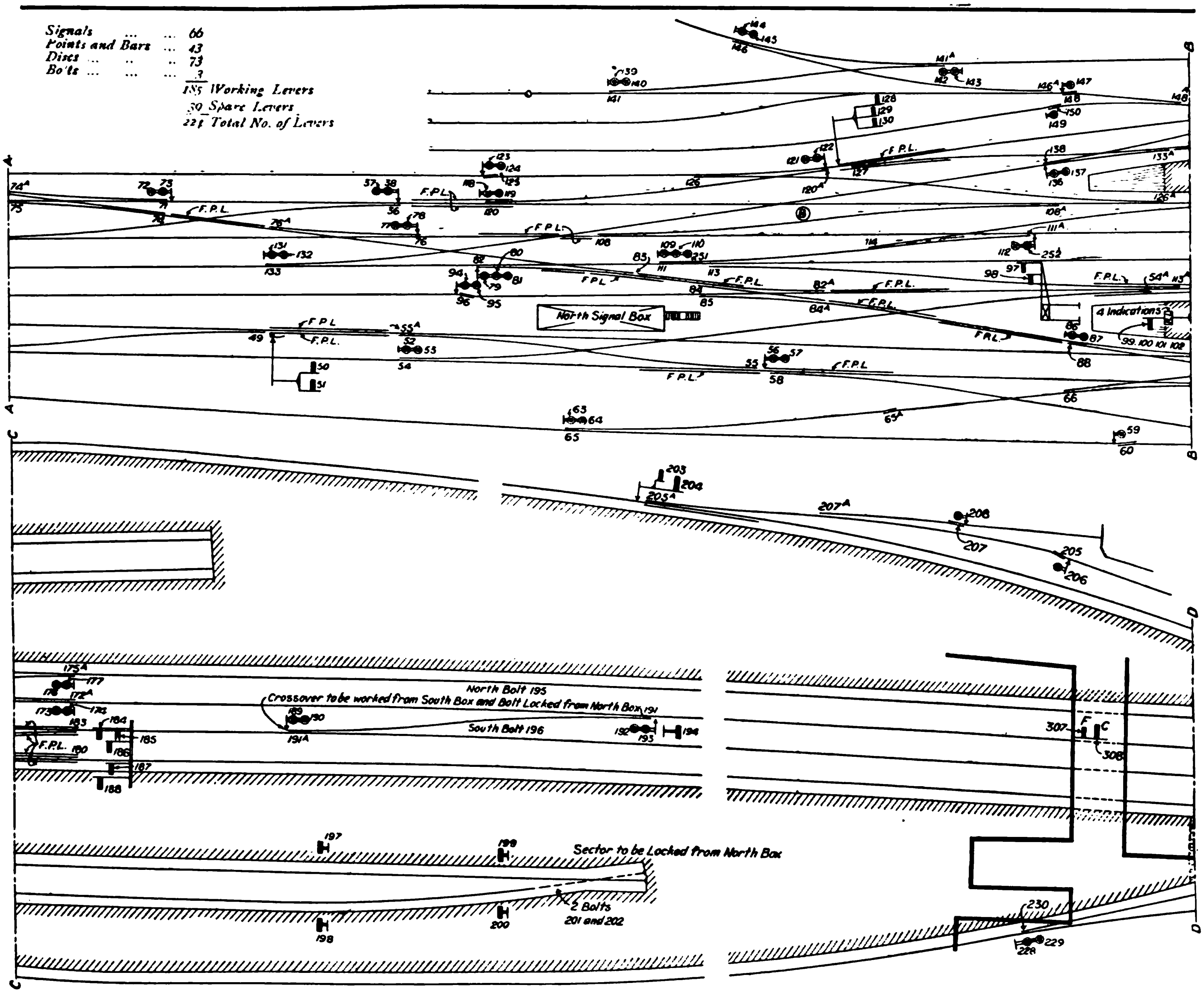
and Co., and which is to be fixed at the new Snow Hill Station, Birmingham, on the Great Western R.

By the courtesy of Mr. Jas. C. Inglis, the general manager and consulting engineer of the G.W.R., and Mr. A. T. Blackall, the signal engineer, there is presented in fig. 1 a diagram of the lines and signals and of the arrangement of the point and signal connections.

It should be understood that the work is not yet completed,

In the North Box there is proposed to be a frame of 224 levers, of which 39 will be spare, and in the South Box 80 levers, of which 15 will be spare.

There are four lines of way north of the station—towards Wolverhampton—and two on the south—towards Bordesley. These fan out into two through lines in the centre of the station and four platform lines, and there will be four bay lines at the north end.



Scissors crossings will be laid in between the through lines and the platform lines next to them. The points, in the up lines, of the scissors will be worked from the North Box, as it will control the approach of trains over them, and the points in the down line will be worked from the South Box for similar reasons.

The crossover road between the through lines will be worked from the South Box, but controlled from the North.

Facing point locks and locking bars will be attached to these points marked F.P.L. Those where the position of the signal does not allow for a bar to be in the rear of the points will be provided with two bars in advance of the points, one on each road.

In many instances one lever operates two, and in one case three, sets of points. Such levers are marked with a number —as 191 for the end nearest the South box of the crossover between the through lines—for the first points and A—as 191A for the second and B for the third.

In all cases one lever operates the F.P. lock and points.

Owing to the presence of a tunnel at the south end the train movements on the up line are attended with difficulty. No passenger train will be allowed to leave the station unless there is a road through, and therefore the departure signals, A, B, C, cannot be lowered until the starting disc G is "off." For shunt movements from the same roads signals D, E, F are employed, and these interlock signal G. The length of the up line between the points of the crossover road and signal G will be provided with train protection bars or a section of "Track-Circuit" so that signals A, B, C, D, E, F cannot be lowered if a train be standing at signal G.

It has been previously mentioned in the *Railway Engineer* that the Great Western Co. now only make their distant signals for approaching a junction to be lowered for the straight line where splitting distants are not provided, also that where speed has to be reduced the distant is kept "On" always. At Birmingham they have had to depart from consistency so far as the down distant signal is concerned. The reason for this is that the station is approached on a severe rising gradient, and therefore drivers should have an early warning as to whether the line be clear. The gradient is against any high speed, and consequently there is no objection to the distant being "off" for entering any road.

Route indicators are provided to those signals marked "R.I." Fig. 2 illustrates how these are worked. In the case *a* are carried a set of discs lettered according to the roads

to which access can be obtained. Eight discs can be provided, and above these are eight hooks spread out over the top of the case, and which are attached to the frame *b*. Each disc has a hook which fits into it but which are all normally out. For each disc there is a lever allotted in the locking frame, and when the road is made, say for the main line, the pulling over of the proper lever will cause the hook to enter the "main" disc and for the signal to be lowered as described

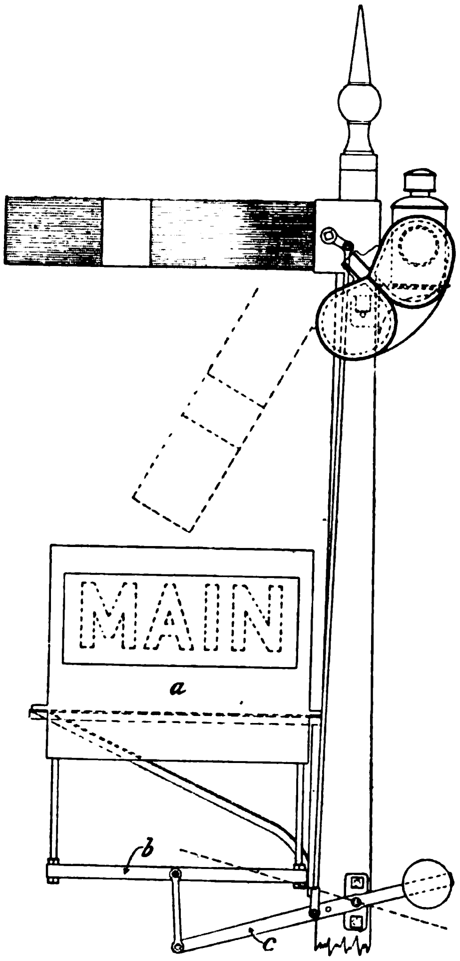


Fig. 2.

in the November *Railway Engineer*. At the same time the lever *c* is raised and lifts the frame *b* and brings up the "main" disc.

It is physically impossible for any but the right disc to be raised, or for it to be raised unless the signal is lowered, and when "off" it cannot fall again until the signal is restored.

Only one motor is used for each signal provided with a route indicator.

Queensland Railways, 1906-7.

THE Report of the Railways Commissioner—Mr. J. F. Thallon—upon the working of the Queensland Government Railways during the year ended 30th June last states that :—

As no new lines were opened for traffic during the year under review the total length remained at 3,137 miles.

The amount expended during 1906-07 was £524,682, leaving an unexpended balance of £1,418,785 at the end of June last. The expenditure for the year 1905-06 was £130,965.

The gross revenue was £1,829,673 and the working expenses £912,638, producing a net revenue of £917,035, or an increase of £234,308. The improvement is not confined to one class, but includes all descriptions of traffic, and, with the exception of the Normanton Railway, extends over all lines.

The increase of £49,282 in the working expenditure is due to increased salaries and wages, restoration of classification increases, increased volume of traffic, and, consequently, additional train mileage. The percentage of working expenses to revenue is 49·88, as against 55·84 for last year, and is the lowest recorded for the last 24 years. The percentage of net revenue to capital expended on opened lines was £4 4*s*., or £1 1*s* 2*d*. more than last year, and is the highest return for the last 24 years.

The revenue and expenditure per train mile, of which so much is made by railway departments generally, are of little use for comparison between States, where each has its own particular gauge and different local conditions; but they are of great advantage in comparing the results of one year with another, and indicate clearly what has been done towards economical working. With this view the following return is submitted, viz. :—

	1904-05.	1905-06.	1906-07.
Number of train miles ...	4,917,781	5,281,611	6,126,136
Revenue per train mile...	5*s*. 9*d*.	5*s*. 10¼*d*.	5*s*. 11¾*d*.
Expenditure per train mile	3*s*. 3¾*d*.	3*s*. 3¼*d*.	2*s*. 11¾*d*.

Last year shows the highest record of earnings per train mile for the last 23 years; and the expenditure per train mile, including, as it does, the highest wages ever paid by the department, is lower than it has been for many years.

The shipment of coal at Brisbane and Maryborough again shows a satisfactory increase for the year 1906-07—namely, 315,859 tons, compared with 243,170 tons the previous year.

The Chief Engineer certifies that the lines have been efficiently maintained. The cost of maintenance per mile shows a slight increase—viz., £84 10*s*. 5*d*., as against £83 3*s*. 9*d*. for the previous year, which is reasonably due to the extra number of trains, but it compares favourably with previous years.

Harrow Road Bridge; Great Central Railway.

IN our issue for March, 1906, we published a description of the new section of the Great Central R. from Neasden to Northolt, accompanied by drawings of the most important of the bridges and other engineering features of the work: we now illustrate one of the less important of the bridges, the drawings of which will, however, not be less useful on that account.

The bridge illustrated carries four lines over the Harrow Road just before the line reaches Sudbury and Harrow Road Station, fig. 1. It crosses the road at an angle of 65°: the skew span is 72ft. 3¼ins. and the square span 65ft. 6ins.

Fig. 2 shows the positions of the girders and details of the abutments. Fig. 3 gives a plan of the bridge and details

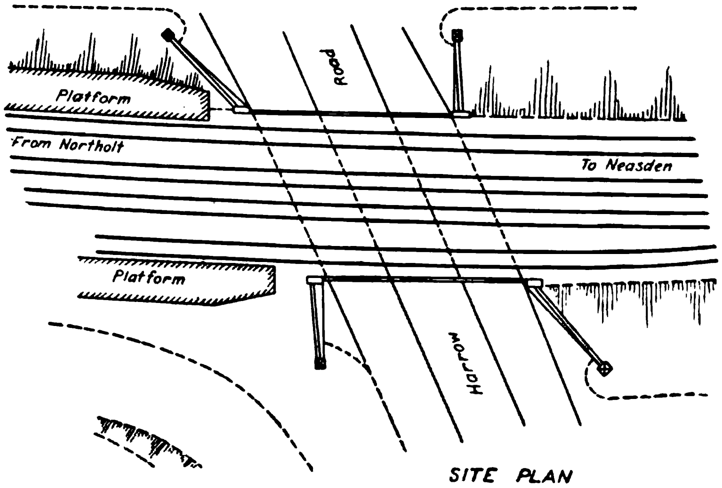


Fig. 1.

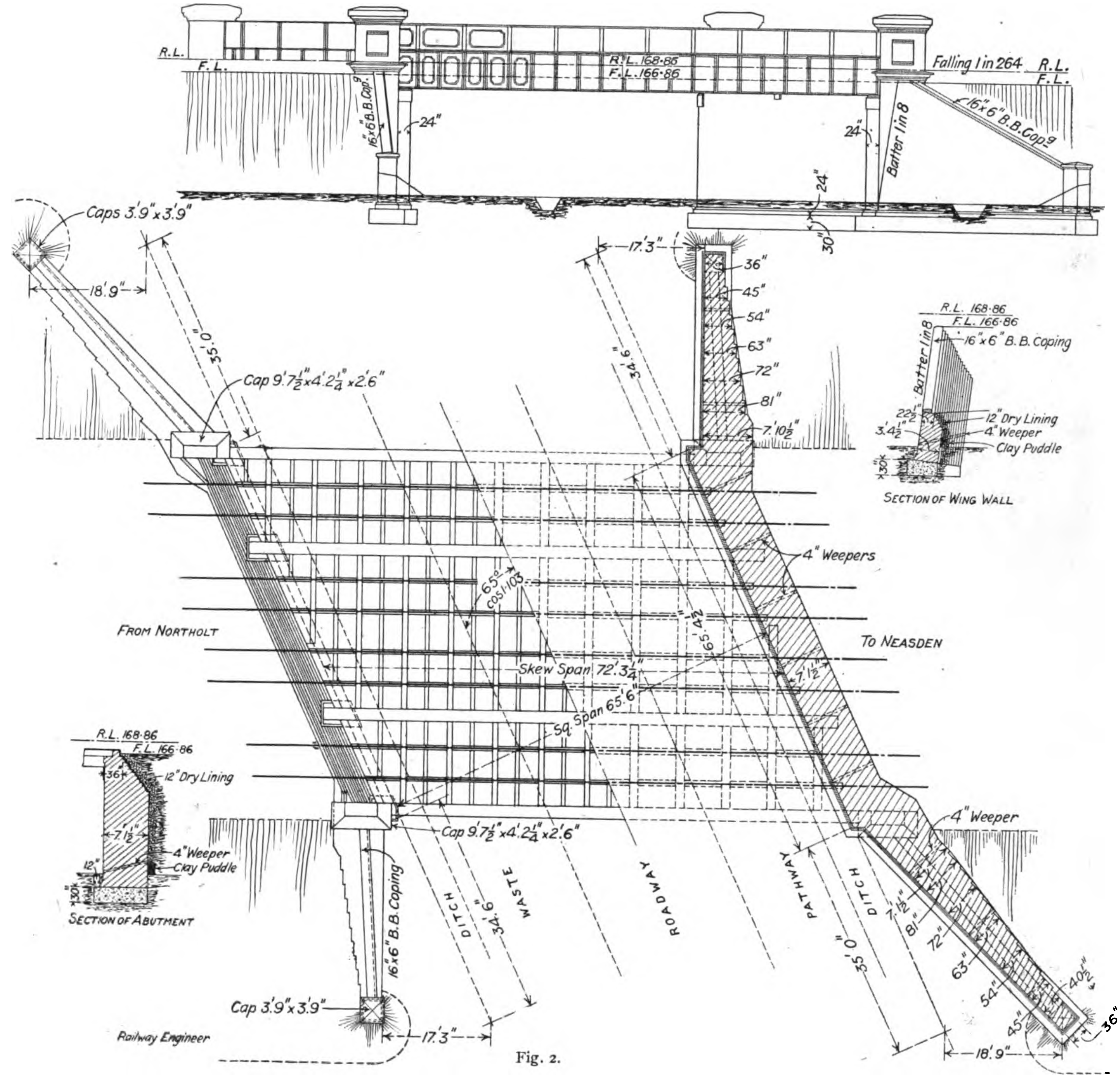


Fig. 2.

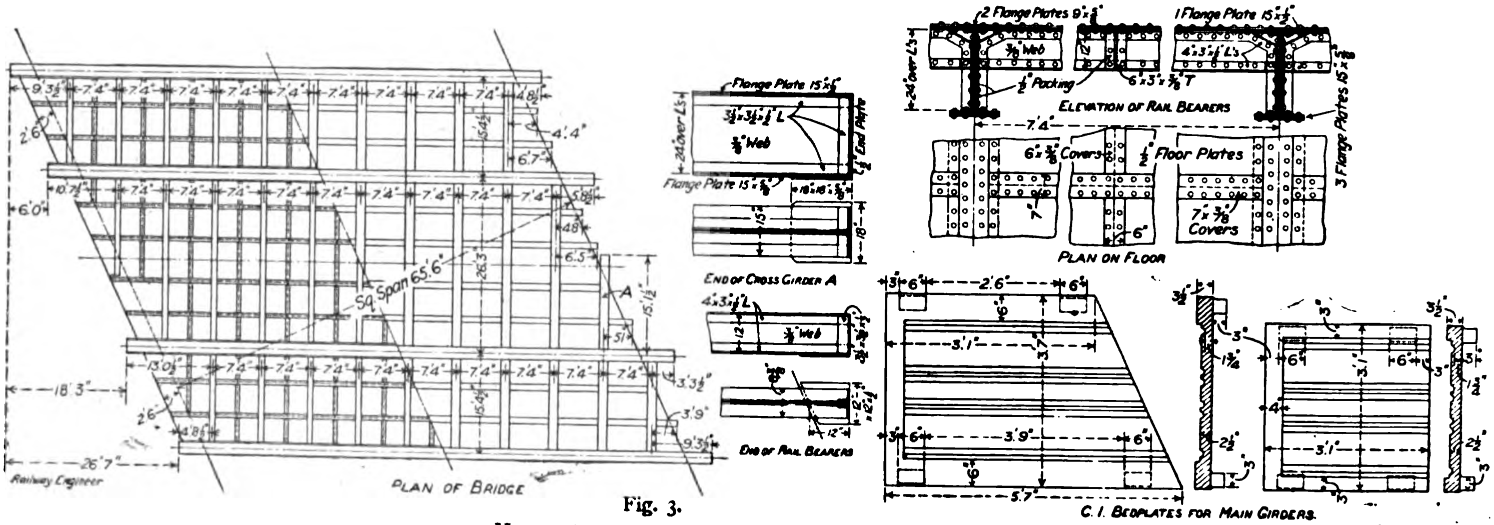


Fig. 3.

Harrow Road Bridge; Great Central Railway.

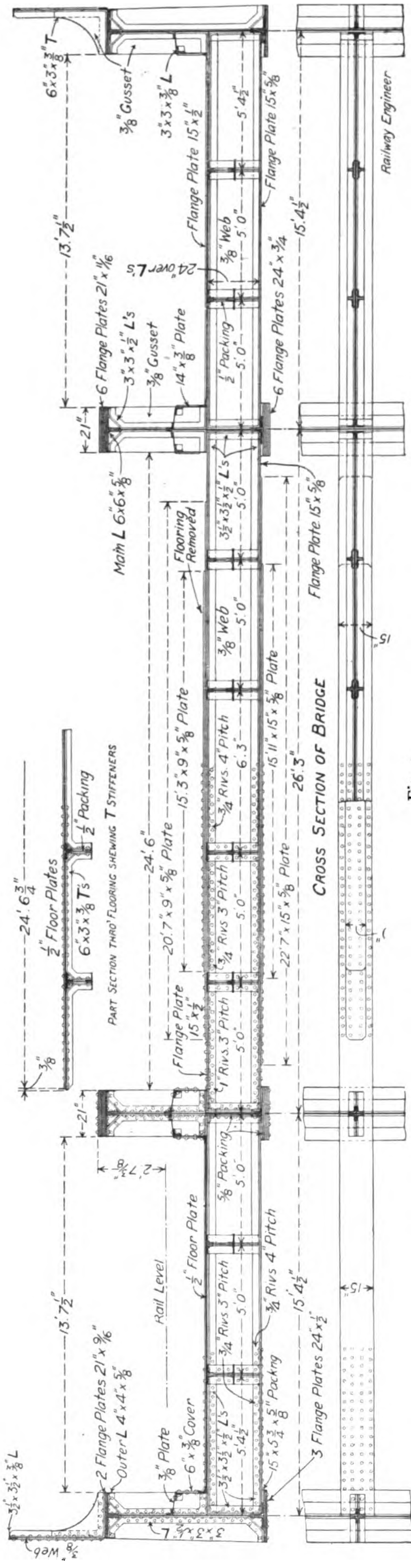


Fig. 4.

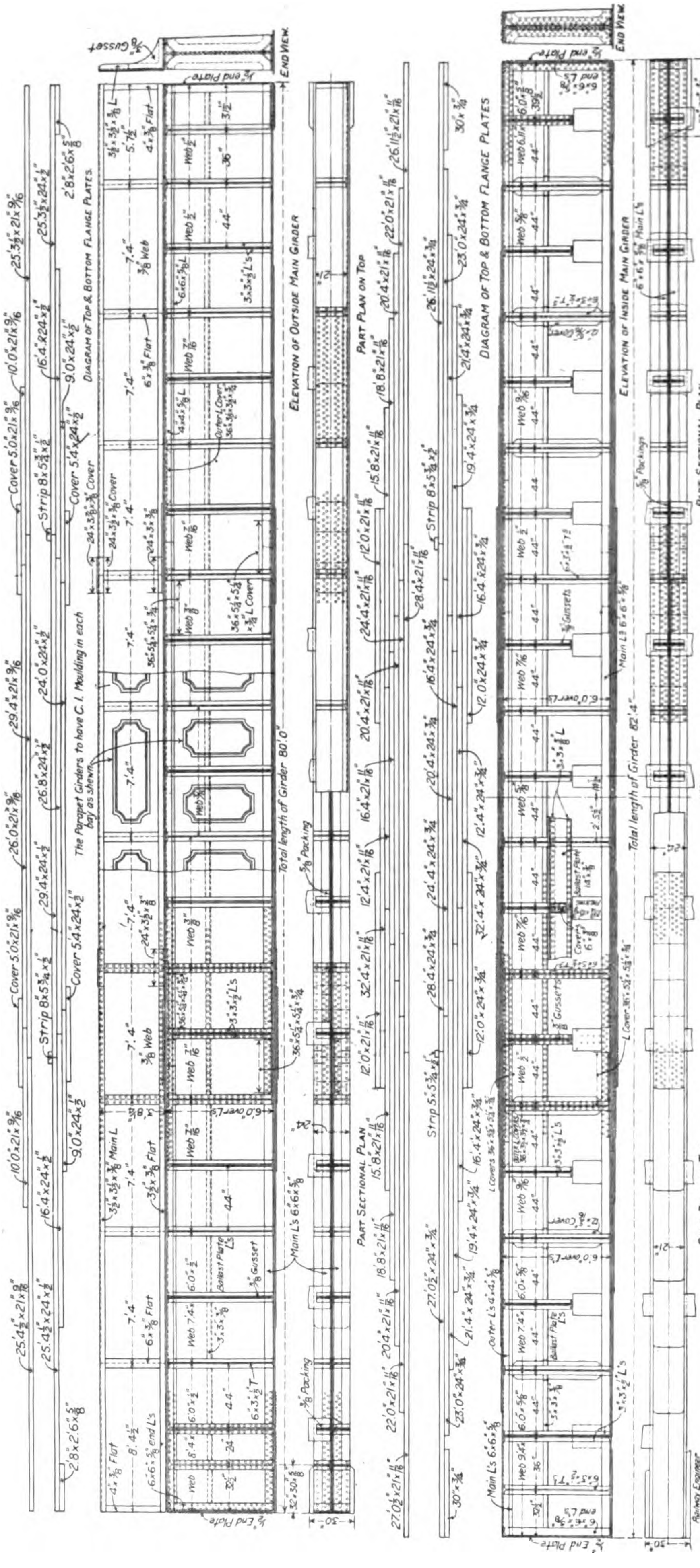


Fig. 5. Harrow Road Bridge; Great Central Railway.

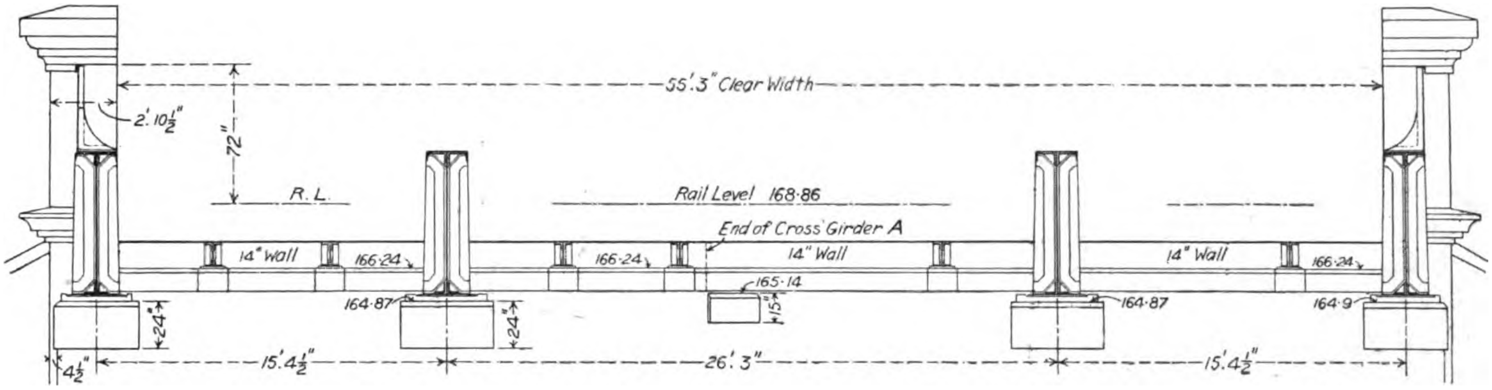


Fig. 6.—Enlarged Cross Section.

of the cast-iron bedplates and the rail bearers and floor plates, which are stiffened by 6 × 3 × ⅜ T's as shown on fig. 4.

Fig. 5 shows fully the two inner and the two outer main girders. They are all the same depth, viz., 6ft. over the angles, and the top and bottom flanges are respectively 21 and 24ins. wide, but the plating of the flanges are quite different, as shown by the diagrams. The outer sides of the outer girders are surmounted with a cast-iron parapet, and the bays are also filled in with ornamental cast-iron plates—see fig. 5. The cross girders are illustrated by fig. 4.

All the rivets in the main girders are ⅞in. diam. and ¾in. diam. in the cross girders, flooring, ballast plates and rail bearers pitched 4ins. except where shown otherwise on the drawings. All the holes are drilled. All packing pieces are in one thickness.

The main girders have a permanent camber of 2½ins. at the middle, and the outside cross girders ½in. and the inside cross girders 1in.

Two of each kind of the bedplates are fluted, fig. 3, and two of each plain; the latter are drilled and tapped for 1½in. stud bolts for fixing the girders, the bearing surfaces being accurately planed.

The Neasden and Northolt line was laid out and the bridges and buildings designed by Mr. C. A. Rowlandson, M.Inst.C.E., to whose courtesy we are indebted for the drawings published.

The Locomotive from Cleaning to Driving.—XII.*

By

John Williams, *Locomotive Inspector Great Central R.*, and Jas. T. Hodgson, *Mechanical Superintendent School of Technology, Manchester.*

[NOTE.—Owing to some of the illustrations not being ready it was impossible to continue the subject of Brakes in this issue, but we shall do so in our next.—Ed. R.E.]

Duties of the Driver.

Having successfully passed through the cleaning and firing stages of his career, the spare driver will, by virtue of the time he has spent upon the footplate, have gained sufficient experience to know that it is practically impossible to obtain or to give information beforehand regarding every difficulty that may present itself during his daily work. So much depends upon outside circumstances, such as signals, amount of traffic on the line, engine failures, etc., that his individuality and discretion, combined with the manner in which he attends to the various details connected with his duties, will always have a direct bearing on his success or failure as a driver. It is during the first 12 or 18 months that the young driver will have to show that his promotion was merited, and a few slight mishaps or casualties during that period may greatly retard his progress, and seriously impair his future prospects. His record will to a certain extent be compared with that of others, who have had many more years' experience, and he may often find himself on an engine not in the best of condition, or with a fireman for mate who is somewhat new to his duties. The following is therefore intended to emphasise the importance of a few of the various details connected with daily work, and which, when properly applied, go to make the successful driver by giving the necessary confidence for the proper discharge of his duties, leaving absolutely nothing to chance.

After having signed the appearance book, and obtained the number of his engine from the sheet, the driver should see what is entered for his engine in the report book. Any special bills or road book that may be necessary should be signed for, and the notice boards carefully examined for orders respecting water, repairs to the line, alterations to signals, etc. To prevent the occurrence of any mishap for which he would be held responsible the driver should write out on paper the stops and running of his train. In this manner any detail affecting the daily work, whether in time book, rules, or special bills, will invariably be committed to memory before starting on the journey.

On some railways, when the return trip cannot be completed in 10 hours, the engine is brought down from the shed to the terminus and backed on to the train ready for the driver and fireman proper to take the train away. When the engine returns the men are again relieved by other men, who take the engine back to the shed. These trips are only given to the best and most reliable men, and may be described as the "blue ribbons" of engine driving. Such engines are generally double crewed, and the men only work 30 hours a week.

After the various notices and instructions have been duly noted, he will go to his engine and first examine the gauge glasses to ascertain the amount of water in the boiler. The water level should be verified by blowing the gauges through, at the same time a glance at the pressure gauge will show whether steam is generating in sufficient quantities, and the fire may be regulated accordingly. A brief glance into the fire box will show the state of the fire, and the condition of the tube ends, fusible plugs and brick arch should be noted. The tanks should next be inspected to make sure that there is sufficient water for the boiler, and the coal examined as to supply and mode of stacking. The injectors should be tested to see that both are in proper working order, and the tools, lamps, fire irons, detonators, etc., overhauled, so that a complete set may be at hand. The engine, assuming it to be "right hand," *i.e.*, right hand crank leading when running in fore gear, should be placed on the pit with the right hand crank on the bottom centre, brake hard on, reversing lever in mid gear, and cylinder drain cocks open. Passing underneath with suitable spanners, all nuts on glands and rod ends should be tested. Make sure that they are securely locked in

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Fig. 33

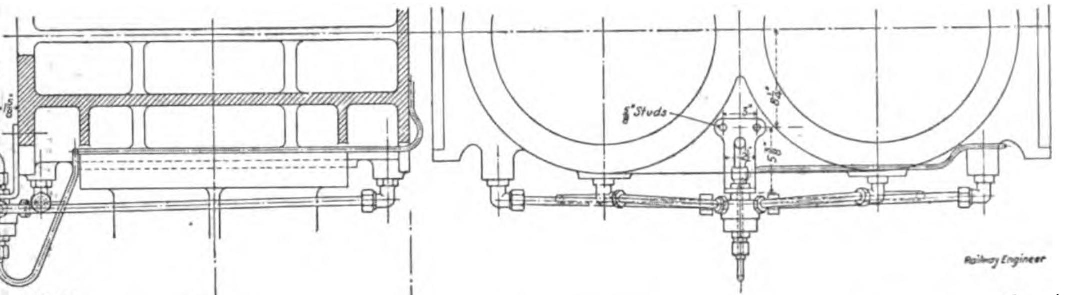
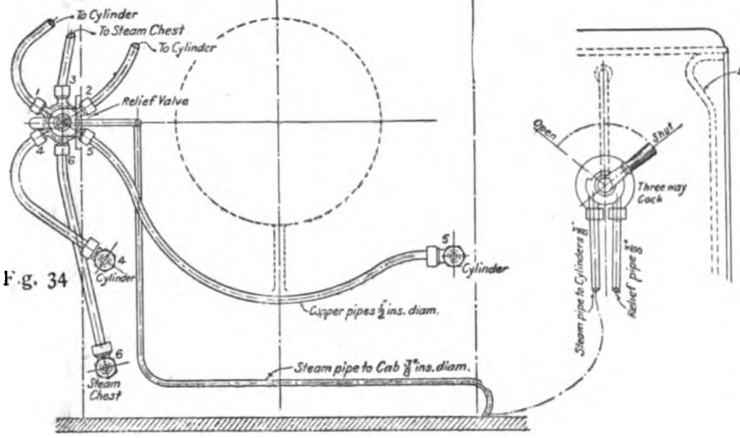


Fig. 34



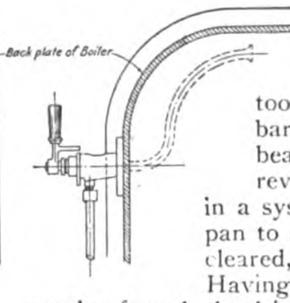


Fig. 35.

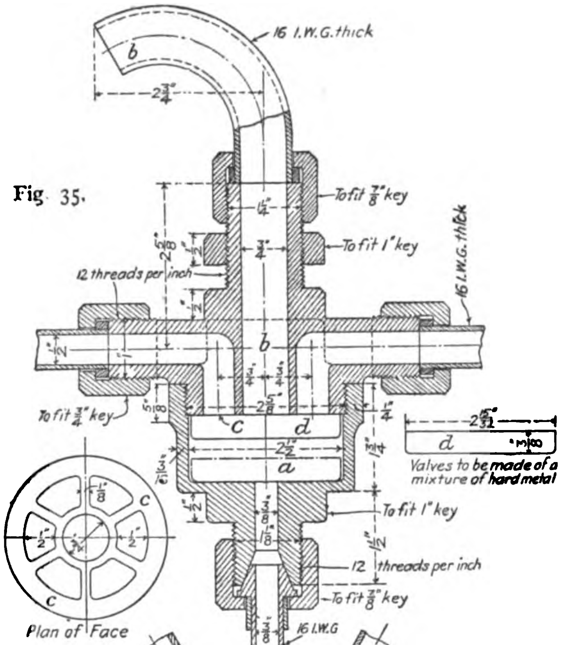
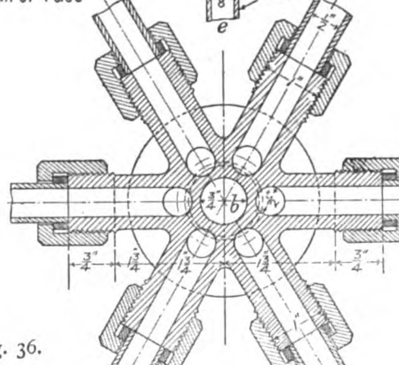


Fig. 36.



may be examined and oiled. At the same time the big ends may be tested for adjustment and the wear taken up if necessary. This should be done by degrees, so that the tendency to knock may be prevented by maintaining the brasses in proper contact with the journals and thus reducing the risk of melting the anti-friction metal by the journal heating up, as would be likely to occur if neglected, or the cotter driven home too tightly. The back and front slide bar bolts, eccentric sheaves, straps, rods, bearing spring connections, and the long reversing rod, etc., should be examined in a systematic manner. Look into the ash-pan to see whether ashes have been properly cleared, and note the condition of fire bars. Having been satisfied that there is a suitable supply of sand, the driver should make sure as to the sanding gear and brake gear on engine and tender being in proper working order, noting at the same time that the hose connections are intact and in good condition. The plug on the vacuum reservoir should also be occasionally removed for draining the accumulated water.

The drip valves and all brake connections having been examined, the driver should then mount the footplate, and pull ejector handle in the "full on" position before opening the small ejector steam valve, otherwise a certain amount of water is invariably discharged from the ejector exhaust pipe in sufficient quantities to dirty the smoke-box and boiler.

With the ejector handle in "full on" position it will be found that this water is mostly deposited in the smoke-box and not up the chimney, as when steam is first admitted with the handle in "Running Position." Having returned his handle to the latter position, the driver, by observing the pointer of the vacuum gauge, can assure himself that the brake is in proper working order. This is also particularly applicable after an engine has been coupled to a passenger train, insomuch that the time occupied in creating the vacuum would denote whether the whole or part of the train had been inadvertently left uncoupled.

The double acting air pump on engines fitted with the Westinghouse brake should be examined and the plug in the main reservoir, as well as the bottom cap of the drip cup, should be unscrewed at least once a week, or more frequently in frosty weather. The air cylinder of the pump should be sparingly lubricated and the oil cup provided on the top of the cylinder should therefore be filled not more than once a day with a suitable lubricant, tallow or other oils of a vegetable character being unsuitable for this purpose.

The best mineral oil should be used for the steam cylinder, and the pump should be started slowly to allow the condensation to escape from the cylinder, thereby preventing the knocking which is likely to occur when the air pressure in the main reservoir is low. The gland packing on the piston rod should be maintained in good condition to avoid the leakage of condensation down the rod and into the air cylinder. The driver's brake valve should be tested in the different positions and an inspection made to see that the proper pressure is retained in the main reservoir when the handle is placed in the "Position Whilst Running."

The underside inspection being finished, the engine may be moved so that both cranks are at the top, that is, equidistant from the top centre, in which position, with the reversing lever put in mid gear, the remainder of the motion work, little ends, drag links, axle boxes, and side rods, etc., may be properly examined and oiled.

This position of the side rods is also suitable for the

position. Lock nuts, split pins, and all such devices are specifically adopted as a safeguard for retaining the various pieces of motion work, etc., in proper position, and the loss of the least of these may lead to dangerous consequences or serious delay. A cursory or incomplete examination is therefore little or no better than none. With the cranks as stated the whole of the crank axle, big ends, motion work, etc.,

examination of the motionwork and big ends, etc., of an outside cylinder engine.

After an engine has been standing for any length of time, it is important that the driver or fireman should make sure the cylinder drain cocks are open, to allow the escape of any water, due to condensation, that may be present in the cylinders when the regulator is opened.

It is also good practice, after a wash out, or when the engine has become thoroughly cooled, to blow steam through the cylinders, not only that they may be properly drained, but also to heat up the cylinder metal, thus reducing initial condensation when the engine commences working.

Broken cylinder ends, bent piston rods, etc., are often due to trapped water in the cylinders, and many valves have therefore been designed, whereby this water (whether due to condensation or priming) may be automatically discharged.

Spencer's Patent Relief and Drain Valves for Locomotives (figs. 33 to 36) is a modern device designed to act as a relief valve for trapped water and also to take the place of the ordinary cylinder drain cocks.

The valve has six passages, 1-6, fig. 34, which are connected to the back and front ends of the cylinders and steam chests respectively, as shown in fig. 33.

These passages open downwards into one common chamber, through ports in a faced surface, and a central passage *b* is also provided, which is in communication with the atmosphere. The faced surface of the ports is covered with a properly bedded plate or disc *d* (fig. 35), which is maintained in position by the admission of steam direct from the main pipe to the underside of the disc at *e*.

The area of the surface exposed to the main pipe pressure is greater than that of the ports in communication with the cylinders, and the disc is therefore held tight against the port faces, until an excessive pressure due to trapped water in the cylinder occurs, when the disc is forced from the face, thus discharging the water through the central port into the atmosphere. A specially designed three-way cock is fixed upon the boiler front-plate in the cab, by means of which the pressure underneath the disc may be relieved, whereupon both ends of the cylinders and steam chest may be drained as with the ordinary cylinder drain cocks.

The driver should see that the right lamps are exhibited when leaving the shed and should back up to his train carefully. He will also be expected to start away without jerking, whether it be goods, mineral or passenger train, carelessness in this respect often resulting in broken draw-bars, etc. The fireman should be instructed how to work his fire to obtain the best results, and should also be taught when and where to fire, so that both can be on the look-out for signals at the proper places.

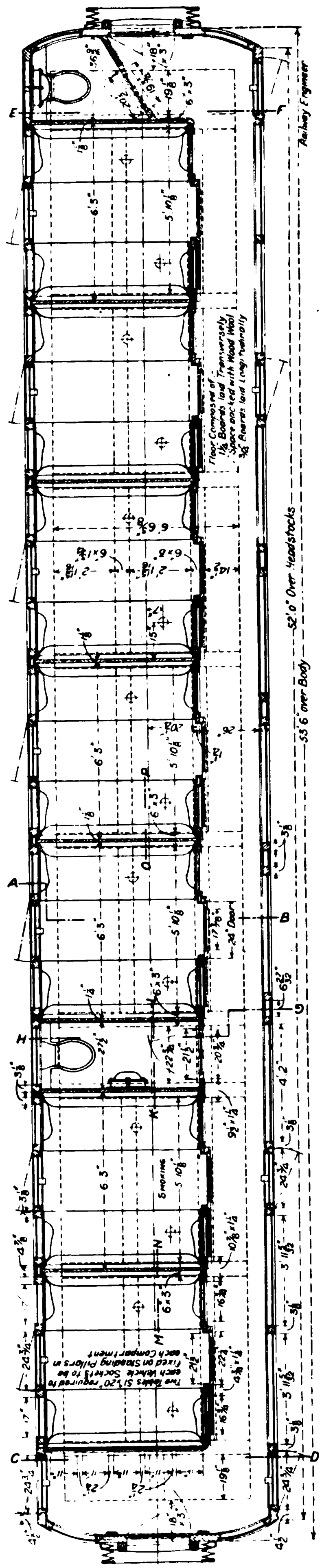
The geography of the road should also be explained, and the fireman shown how to prepare his fire when approaching a rising gradient. Special attention should be paid to the regulation of the boiler feed supply, and the dangers of too much or too little water in the boiler clearly explained to the fireman. The locality of the junctions, crossings and curves must be thoroughly known so that the speed may be reduced to its proper limit at the right time. This point should not require emphasising, seeing that the consequences of disobedience to the regulations are so serious.

A driver will require to have been on the road some considerable time and to have also been very observant before he can form anything like an accurate estimate of speed from the swing of his engine, the velocity at which standing objects are passed, or the sound of the rails, etc. Although the method or instinct by which the speed is estimated is only acquired after years of training, it is undoubtedly advisable to use some definite or absolute method to assist in the acquisition of the necessary power of judgment. The telegraph poles alongside the line, for instance, are usually placed from 60 to 70 yards apart where the road is straight and thus form a ready means whereby the distance travelled by the engine in a given time may be determined. There are 1,760 yards in a mile, and taking the distance between the poles as 60 yards there will be 29·33 poles fixed to the mile, so that after allowing for slight curvatures or deviations in the road 30 poles will be a fairly accurate and very convenient unit upon which which the calculations may be based. The speed of a train is generally expressed in miles per hour, and it is therefore obvious that if travelling at the rate of 60 miles, which equals one mile a minute, 30 poles must be passed in that time, and from this we obtain the general expression that double the number of poles passed in a minute gives the speed in miles per hour. Under certain conditions of weather and locality the poles will be invisible or otherwise not available, and some other means of measuring the rate of speed will therefore be necessary. The usual length of a rail on the straight is 12 yards, so that a definite relation between the number of rails and the number of poles exists. Thus if the 1,760 yards constituting a mile be divided by the 12 yards rail lengths it will be found that there are 146·6 rail lengths to the mile, and seeing that the distance between each pole divided by the lengths of the rails, 60 yds. ÷ 12 = 5, gives 5 rails to the pole, or 150 rails per mile will be accurate enough for ordinary purposes, hence 150 rail lengths per minute equals 60 miles per hour.

75 rail lengths per minute = 30 miles per hour.

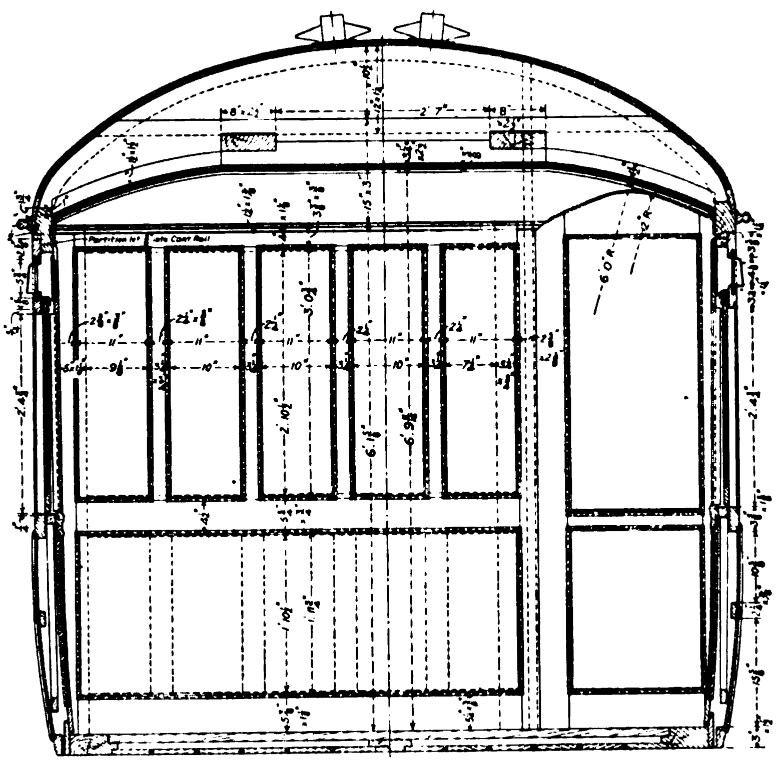
25 rail lengths per minute = 10 miles per hour.

If divided up with 150 rails and 60 seconds as

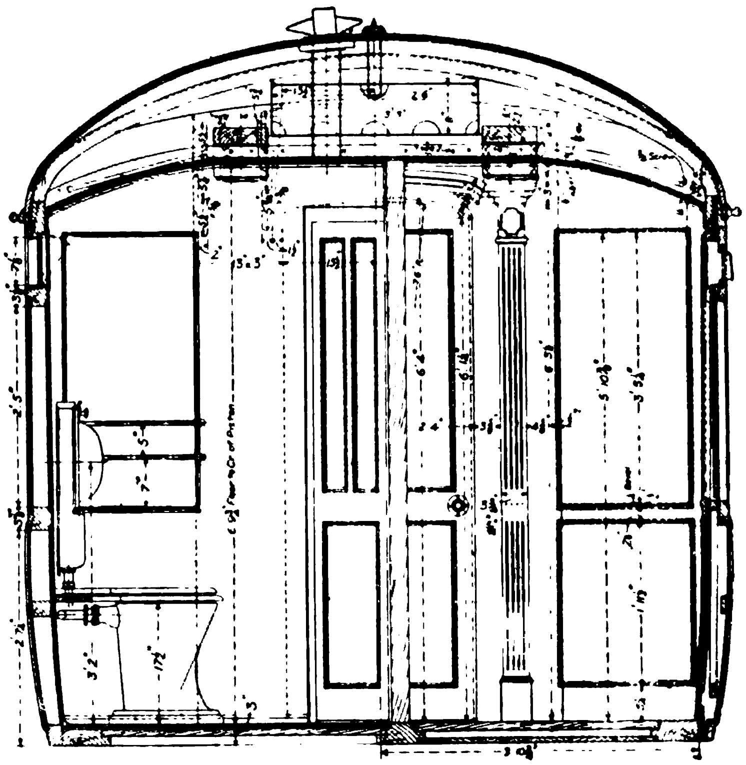


53ft. 6in. Third Class Corridor Carriage; East Coast Joint Stock.

E



Section on Line C.D.



Section on Line E.F.

constants it will also be found that the number of rails passed in 24 seconds is equal to the number of miles per hour, so that 24 seconds is the only quantity that need be remembered.

Seeing that the number of poles per mile varies with the different companies, and that the length of rails may also be different, some general rule adaptable to the various systems will no doubt be appreciated. It will be noted that the number of seconds bears a constant ratio to the number of poles or length of rail, hence when travelling at 60 miles per hour, each pole, when 30 to the mile represents 2 seconds of time and 24 seconds or twice the length of the rail in yards is the unit upon which is based the method of obtaining the speed by rails. From this it is evident that, whatever the pitch of the poles or length of rails may be, the number of poles passed in as many seconds as the poles are yards apart, or the number of rails passed in as many seconds as the rails are yards in length multiplied by 2 will give the speed at which the engine is travelling in miles per hour. Thus, by using the equal yards and seconds any speed may be approximately calculated, *e.g.*

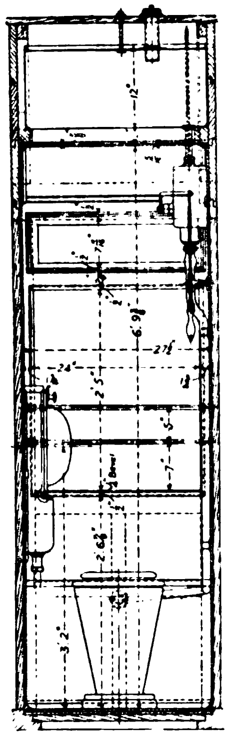
Poles		Yds. apart.		Seconds.		Miles per hour.	Poles.
30	at	60	passed in	60	=	60	or 30 × 2
30	,,	65	,,	65	=	60	or 30 × 2
30	,,	70	,,	70	=	60	or 30 × 2

or

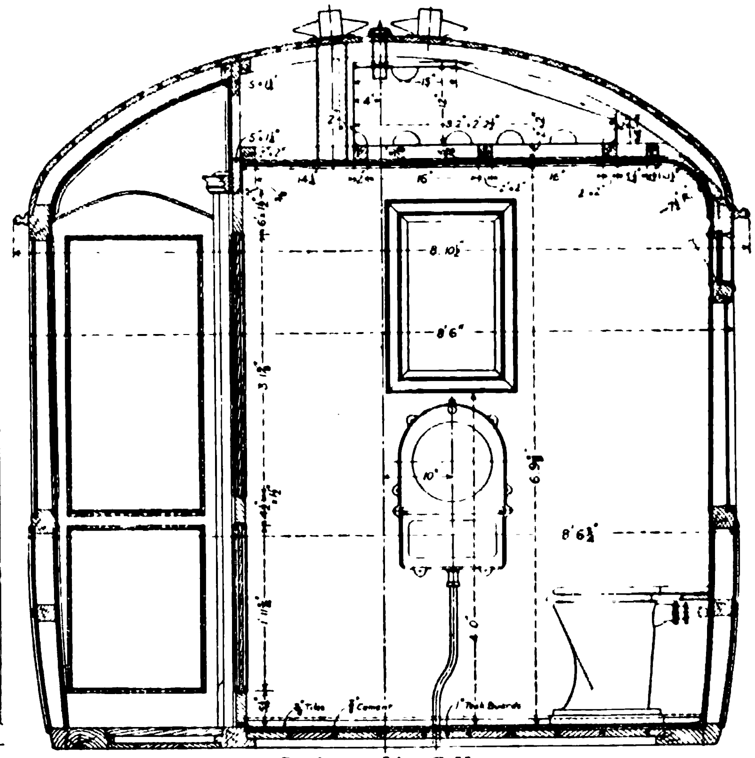
Rails.		Yds. long.		Seconds.		Miles per hour.	Rails.
15	at	12	passed in	12	=	30	or 15 × 2
10	,,	12	,,	12	=	20	or 10 × 2
5	,,	12	,,	12	=	10	or 5 × 2

or any other length in yards as 20 × 2 at 10 yds. long in 10 seconds = 40 miles per hour, and so on.

(To be continued.)



Section on Line K.L.



Section on Line G.H.

53ft. 6in. Third-Class Corridor Carriage; East Coast Joint Stock.

53ft. 6in. Third-Class Corridor Carriage; East Coast Joint Stock.

In our last issue we illustrated the new 58ft. 6in. E.C.J.S. 3rd-Class Corridor Carriages designed by Mr. Wilson Worsdell and built at the North Eastern carriage works at York, and we now illustrate some similar but shorter carriages. It will be seen that the lavatories are differently arranged and that there is one compartment less. The necessary cross sections and plan are annexed, but detailed dimensions of the elevation, etc., and description will be found on pp. 377-381 of our last issue, also the cross sections A B, M N, and O P.

The Signalling and Interlocking on the Electric Zone of the New York Central and Hudson River Railroad.

ONE of the largest signal contracts that has ever been awarded was that given by the New York Central and Hudson River Co. to the General Railway Signal Co. for the signal work in connection with the re-construction of the Grand Central Station in New York City, the widening of the Harlem and Hudson Divisions and other works in connection with the electrification of the lines in what is officially known as the "Electric Zone."

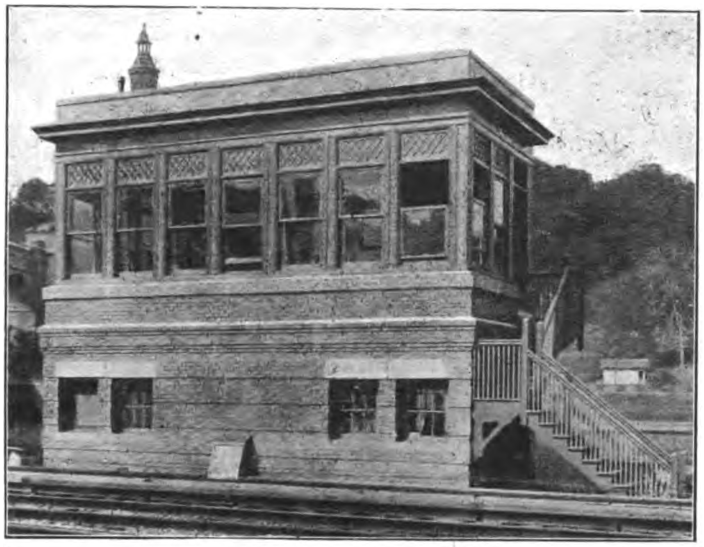


Fig. 1.—Standard Signal Tower.

The size of this work may be judged by the fact that in a length of 50 miles there will be, when the work is completed, 50 signal boxes, 3,000 working levers, 350 automatic stop signals, 350 automatic distant signals, 1,000 semi-automatic stop signals, and 300 semi-automatic distant signals.

The method of operation employed at the interlocking plants is on the lines of the Taylor plant described in the *Railway Engineer* of August, 1902 (p. 238, Vol. XXIII.)

The type of signal tower—or signal box — may be judged from fig. 1, which illustrates the New York Central standard signal box, while fig. 2 gives a view of the interior of the same box and shows the back of the locking frame without the cover. The Taylor frame, a front view of which is given in fig. 3, was described in the previous article above referred to, so that all that is necessary now is to draw attention to the handles of the slides — the equivalent of the levers—the clasp-handle catch A for retaining the lever in position (an addition since the previous notice) and the vertical tappet interlocking with four bars in a groove. In fig. 2 will be noticed the relays and terminals and practically the whole mechanism. The magnets, B, fig. 3, over most of the slides actuate locks connected with "Track-Circuits," and most of them are for "holding the road."

This is known in America as "approach locking" and is provided for all main-line switches whereby they are held as soon as a train has reached a point at least one mile in the rear of the distant signal. On the Electric Zone this is carried out very effectively. For instance, when the road is made for a train to pass through a crossover junction as from a fast to a slow line, all the switches on the slow line that are affected are held. Where "approach locking" is used it is necessary in order to guard against the signalman locking himself up in case he sets up the wrong route to provide a hand-screw release C, fig. 3, and which, by taking some time to withdraw the locks out of the tappets, permits the route to be changed after the lapse of 1½ minutes after the signals have been restored.

The practice, now becoming common in America, of using a section of "Track-Circuits" operating locks B, fig. 3, instead of locking bars (detector bars) for holding facing points whilst trains pass over them has been adopted in this work.

Illuminated diagrams, called illuminated track indicators, and similar to those on the District and Tube Rs., are provided throughout. They differ to those used here, as an unoccupied track is indicated by white lights and a fouled track by red. Something of this sort is necessary in such places

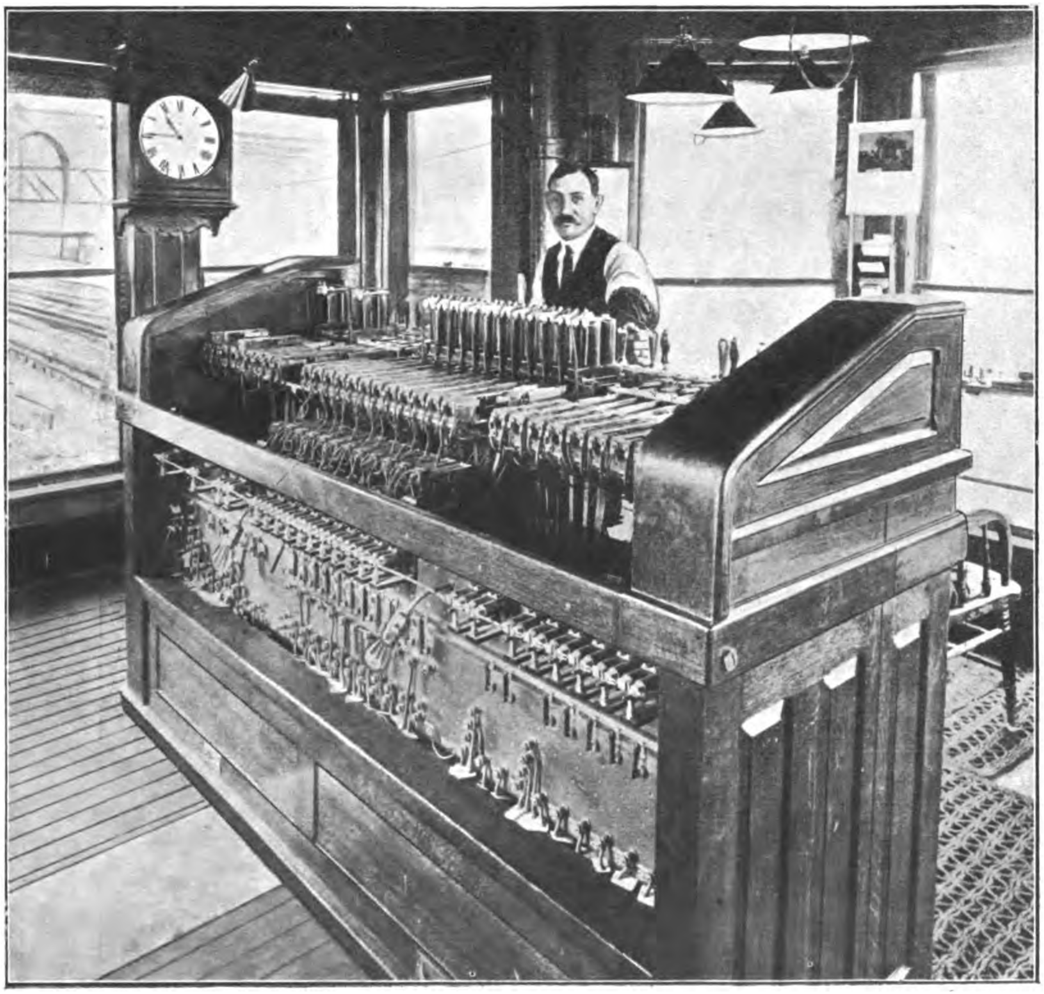


Fig. 2.

as the Grand Central Station, where the signalman will be unable to see his points and the roads he controls.

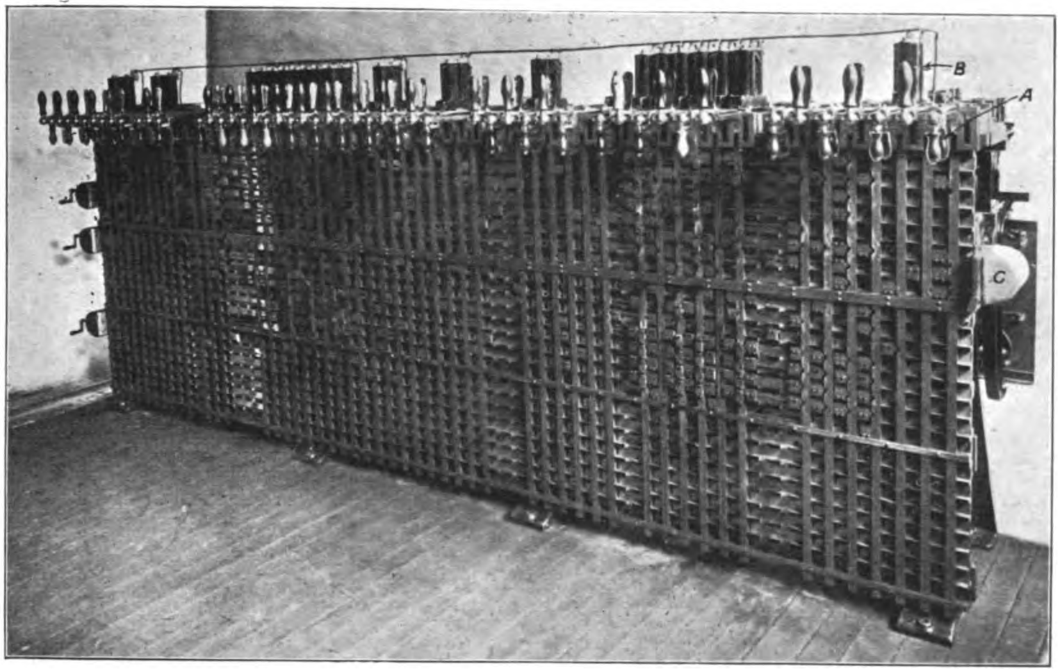


Fig. 3.

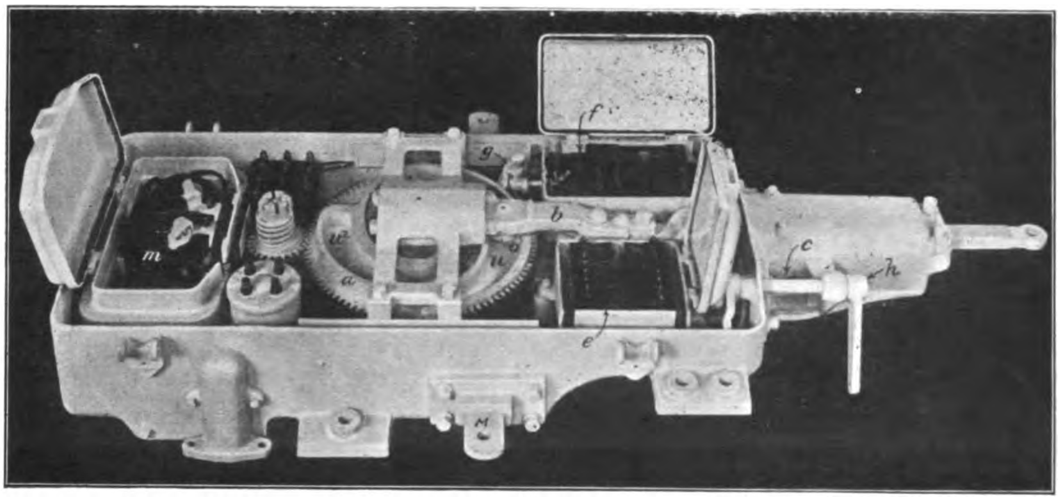


Fig. 4.—Point Mechanism.

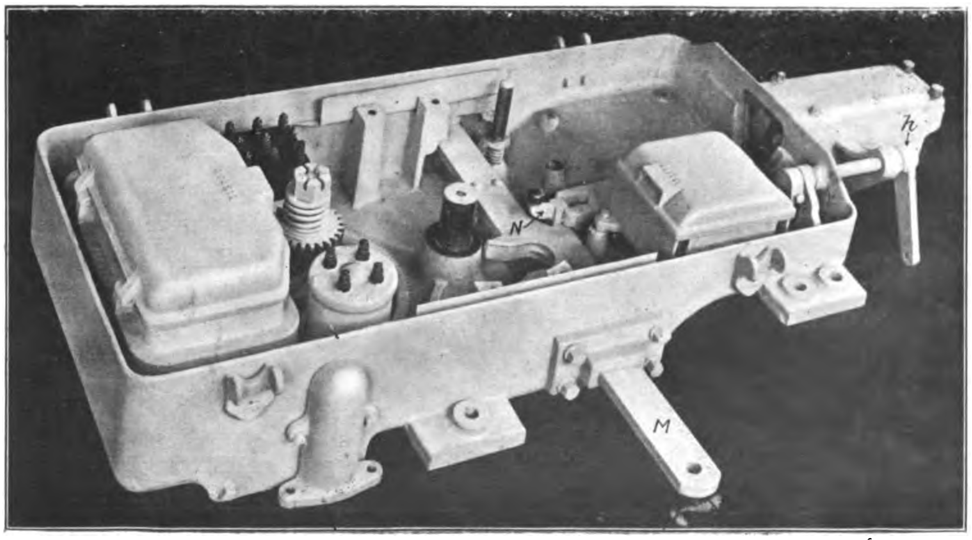


Fig. 5.

Fig. 4 illustrates the switch operating machine, which is small and compact, allowing it to be placed between the tracks and in cramped quarters. It can be bolted to the sleepers. It consists of a vertical motor operating a cam through a train of gears, the sequence of operation being (1) raise locking bar, (2) unlock, (3) throw points, (4) lock, (5) lower detector bar. The mechanism contains switch box, reversing mechanism, and relay for use when operating both ends of a crossover. The mechanism is self-contained and no part is above the top of a 6in. rail when resting on extended sleepers.

Fig. 5 shows the machine with main cam gear wheel *a* and the locking rod *b* removed. Fig. 6 is a view of the upper side of the cam gear wheel and fig. 7 is a view of the lower side. Fig. 8 illustrates the locking rod.

To the underside of the locking rod *b* are two rollers O O², the former working in groove U and the latter, O², in groove U², and when the motor *m* is energised the cam wheel *a*, by suitable gearing, is revolved in a direction from the upper left

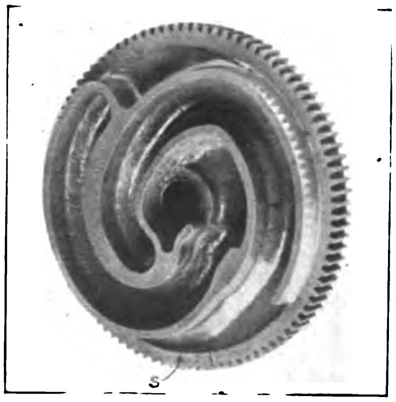


Fig. 6.

Fig. 7.

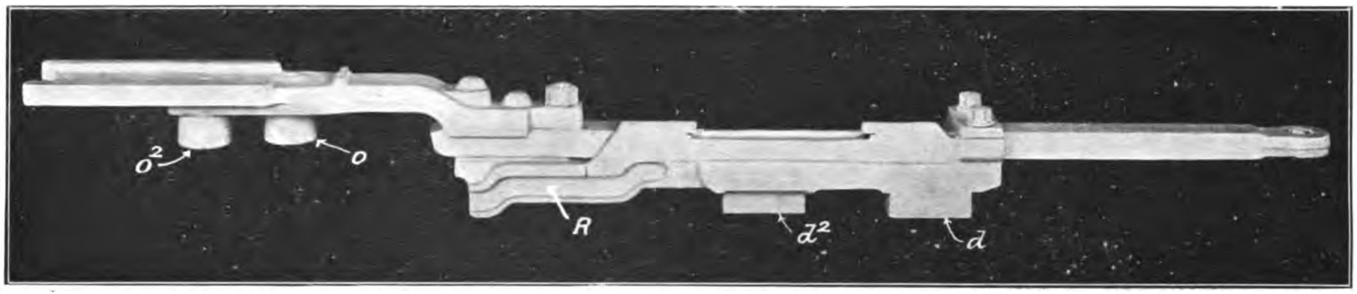


Fig. 8.

to the upper right, and by means of the rollers O O^2 a right to left movement is given to the locking rod *b*, to the end of which is coupled the usual locking bar. The first movement is to raise the locking bar so as to ensure that no vehicle be on the points, and this is done by the initial travel of the locking rod. Through the hole *c* pass two rods– one from each switch in which is normally the dog *d*, and when the switches are over they are held by the dog d^2. On each side of the locking rod is a slot (R, fig. 8) in which works a pin on a crank. One crank works the signal circuit controller *e*, and the other crank works the pole changer *f*, and the first movement of the locking rod causes the slot R to turn the signal circuit controller contacts to a central position, and to close the circuit of the pole changer coils to correspond with the movement to be made.

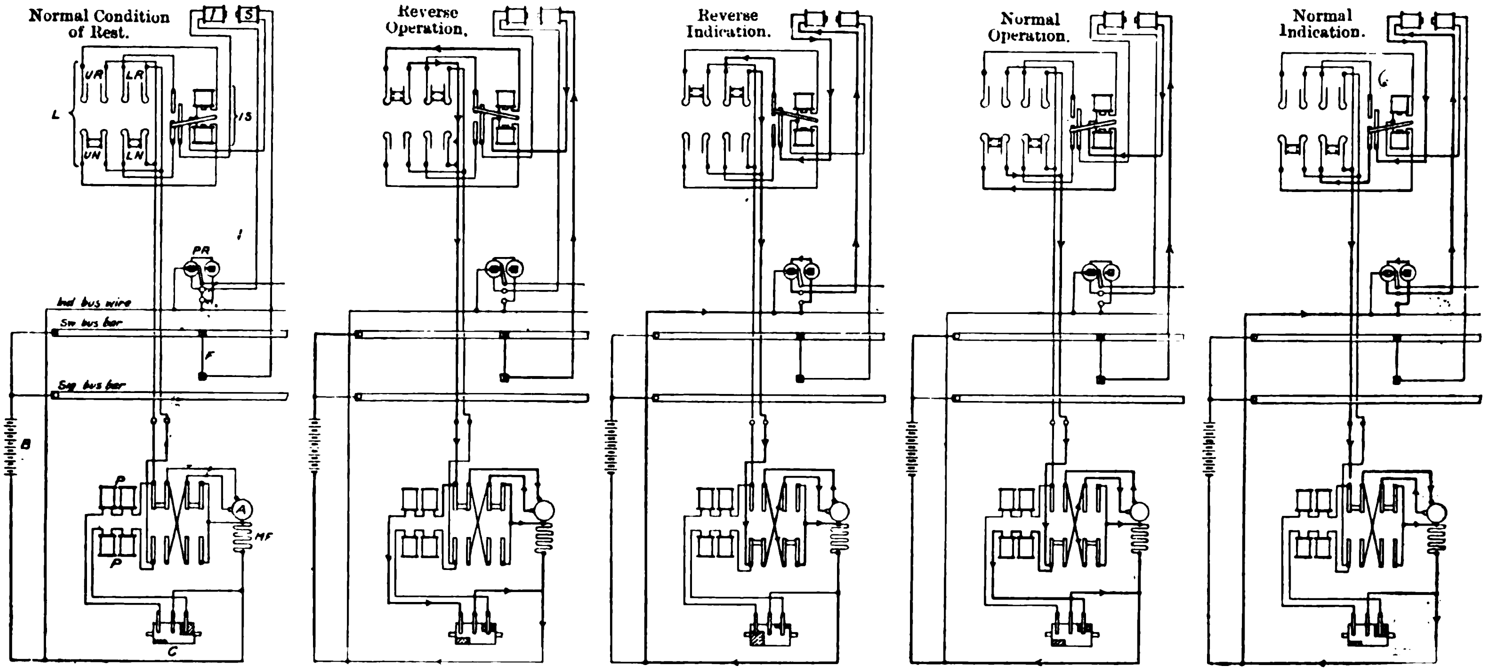
The roller V, fig. 7, on the under side of the cam gear engages in the jaw of the operating rod M fig. 5, by the way, shows the rod in a different position to that in fig. 4—but not until the cam has revolved some distance. There must first be withdrawn the lock N which holds the operating rod. The roller on this lock travels in the groove T and it is forced from left to right before the roller V engages with the jaw in the operating rod, and then, when the latter is over and the points have been moved, the groove T brings the lock N back again and it holds the operating rod in its "over" position. This is a novel feature of much value.

Whilst the operating rod is travelling, the rollers O O^2 have remained stationary, but when the rod M is over the grooves of the cam gear *a* carry them further to the right. This causes the pins in the slots R to give a further and complete movement to the signal circuit controller, and the pole changer is set and the locking bar is pushed over to its other position. When the movement is completed the raised pieces S S on the cam gear comes against the wing *g* and turns it so that the pole changer is put fully over and the motor stopped.

The signal circuit control is not only operated by the locking rod, but by the points themselves. Attached to the latter is a rod coupled to the crank *h* which lowers the moveable contact in the switch box so that the circuit is not complete by the locking rod alone but by the points being "home." This is another novel and valuable feature.

The "Return-Indication" switches lie behind the pole-changer *f* and they are moved at the same time as the pole changer. The current from the "Return-Indication" switches to the locking frame is generated by the inertia of the motor after the points are over and the current cut off.

Fig. 9 is a diagram of the wiring and shows the five states:—Normal condition: lever partly over to reverse points. "Return-Indication" come in and reverse movement completed: lever put part to normal: "Return-Indication" come in and normal movement completed. The heavy



A—Motor Armature. B - 110 Volt Battery. C—Pole Changer Contactor. F—Fuse. I- Indication Magnet. IS—Indication Selector. L—Lever Con rollers. LN—Lower Normal Contact. LR—Lower Reverse Contact. MF--Motor Field. P—Magnetic Pole Changer. PR—Polarized Relay. S - Safety Magnet. UN—Upper Normal Contact. UR—Upper Reverse Contact.

Fig. 9.

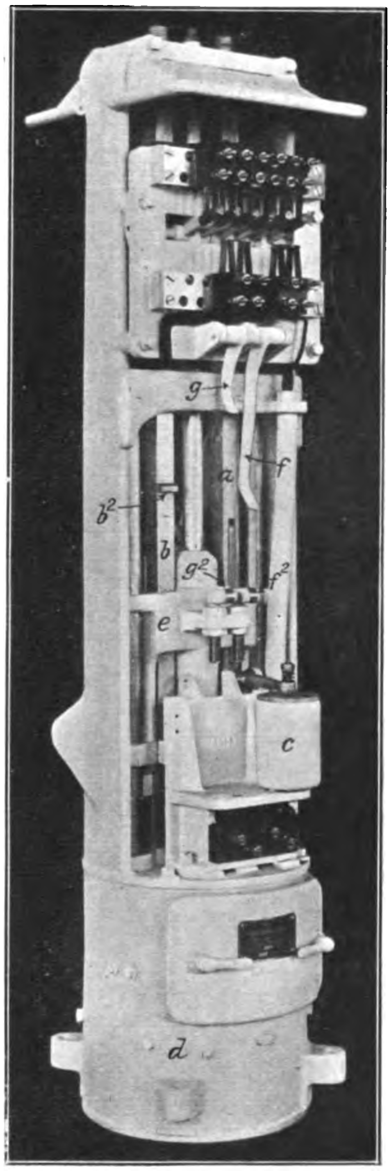


Fig. 1c.

lines indicate those wires carrying current and the arrows its direction.

The signals that are worked from locking-frames are provided with operating mechanism such as is illustrated by fig. 10. This is for a two-arm signal an upper stop arm and a lower distant. The former signal is coupled to the upright rod *a* and the distant to rod *b*. The magnet *c* is energised from the "Track-Circuit" and attracts its armature, when the section is clear, so that a slot on the upright-rod is engaged and allows the arm to be lowered. In the base *d* is a motor which, when driven, raises the frame *e*. If the slot in rod *a* is engaged that rod is raised until the roller f^2 gets under the cut-out lever *f* when the motor is stopped and the signal-arm is held "off" by a clutch in the base *d*. If the distant signal may be lowered, or when it may be lowered, the motor continues running and the frame *e* rises further and engages under the stop b^2, raising the rod *b* until the roller g^2 gets under the cut-out lever *g* when the motor is again cut out and the clutch holds the signal "off." The switches above the cut-out levers are the circuit breakers.

The dwarf signals, fig. 11, are operated by a motor which drives a cam in which works a pin coupling the upright rod. As the cam revolves the pin is raised and the upright rod, and so the signal is lowered.

Where two arms are on one post a double field reversible motor is used so that the direction of the motor determines which arm shall be lowered.

In the front of the case is a coiled spring A which is wound up as the motor revolves. When the signal is to be restored to danger the spring is released, and this drives the motor armature in the reverse position and gives the dynamic indication.

The type of dwarf signal employed on this work has one special advantage—its compactness, and being built in sections can readily be converted from a two-arm to a one-arm signal and *vice versa*.

In the basement of each signal box is a motor generator with the usual switchboard, whereby storage batteries, in an adjoining building, are charged for supplying power for the operation of the points and signals. The motor generator consists of a single-phase induction motor, direct connected to a shunt-wound generator. The motor is supplied—except in the Grand Central Station, where 300 volt primary

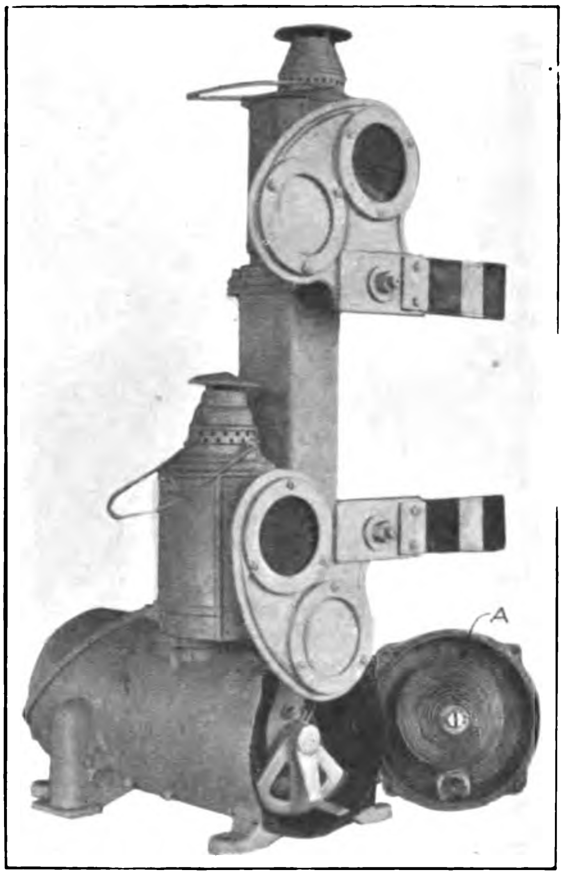


Fig. 11.

is used from a 2,200 volt 25 cycle single phase line through static transformers having 110 volts secondaries.

In the starting position a non-inductive resistance and a reactance are connected in series with the motor field. The resistance and reactance cause a sufficient phase displacement in the windings to set up a distorted revolving field effect, sufficient to give a good starting torque.

In the running position two terminals of the field are direct connected to line. The change from starting to running positions is accomplished by a double throw switch.

The regulation of the generator is accomplished in the usual manner by means of a field rheostat, the switchboard connections being arranged for self-excitation when charging the 110 volt battery, or the 110 volts and 10 volts batteries in series, and for separate excitation from the 110 battery if it becomes necessary or desirable to charge the 10 volt battery separately.

These batteries are in a separate building so as to keep the fumes away from the signalman and the apparatus. The storage batteries consist of 55 cells, of capacity varying from 80 to 320 ampere hours, and the average time between charging is four days.

The whole of the Electric Zone is to be equipped with automatic signals and the running signals at interlocking plants are to be semi-automatic. The purely automatic signals are operated by alternating current derived from the two great power stations that supply the motive power for the trains. These stations deliver three-phase alternating

current of 25 cycles and 11,000 volts, which is converted at the various sub-stations into direct current, at 666 volts, to the third rail for operating purposes. Transformers are provided at these sub-stations which reduce the alternating current for the signals to 2,200 volts, and it is conveyed to the signals by a special single phase transmission line.

Each sub-station is provided with a switchboard for the signal system (fig. 12) together with automatic and hand-operated switches. Should the alternating current supply fail, D. C-A. C. motor generators, fixed in the sub-station and taking current from the reserve storage batteries that are provided for traffic operations, will continue to feed the signal transmission line.

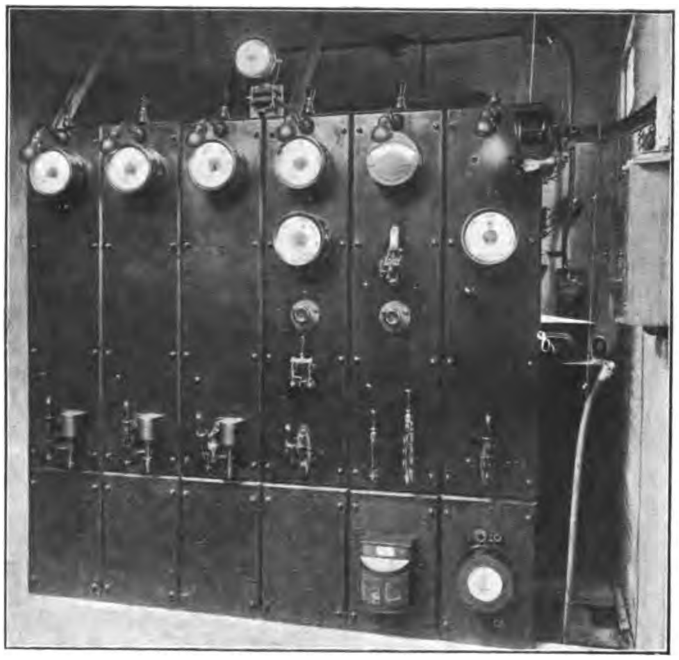


Fig 12.

The system of cross-protection designed by the General Railway Signal Co. for this work is worthy of some explanation. The principle is the opening of the main switch by the reversal of the direction of the flow of current in one or more conductors. This is accomplished by a switch held in the closed position by electro-magnets which switch controls the supply of current to all functions.

In fig. 13 this switch is seen at A, the indicator circuits are B B, the magnet windings of the circuit breakers are C, and D is the reverse current control of these windings.

In the normal operation the winding C is connected directly across the terminals of the battery through the contacts of the reverse current control (polarised relay).

The indication current, except that for dwarf signals—where battery indication is used—flows through the main common, the indication common, polarised relay coils D, indication Bus bars, controller contacts, and control wire, back to the function tending to keep the contact E closed. The polarised relay consists of a powerful permanent magnet, one pole of which carries a small horseshoe electro magnet and has a small armature pivotally mounted on the other pole, so located as to swing between the poles of the electro magnet, one of which carries an insulated contact point. The windings of the electro magnet are so arranged that the normal flow of the indicating current is such as to hold the pivoted armature against the contact. Immediately the current is reversed, however, the pivoted armature is thrown over to the other side, opening the circuit of the circuit breaker coils.

It will be noted that all control wires are normally connected to the negative side of the battery through the indication bus, coil D, indication and main commons, and that if a cross occurs on any control wire at a time when its controller is not in an operating position, the current will flow through the function tending to operate it improperly, and at the same time to flow through the coil D in the reverse direction tending to open the contact B.

The resistance of the coil D is so much lower than that of the various motors, that the greater portion of the current passes through D, the winding of which is so proportioned that a current sufficient to operate any motor, passing through it, will instantly open the contact E, thus causing the circuit breaker to open and stop all movement.

The indication common is carried out to some distance from the signal box in order to prevent the drop in potential in the main common, due to the simultaneous operation of several switches, causing current to flow back to negative through all control wires that are not in operative connection, which current, having necessarily to pass through the coil D, would, in case of excessive drop, cause the contact E to open unnecessarily.

In order to prevent the circuit breaker from being held closed improperly, the circuit breaker relays B (in which *a* is the main and *b* the operating winding) are introduced to control the main current supply by a contact in series with the circuit breaker, and in order to prevent the unnecessary setting of signals to danger, when circuit breaker opens, the resistances G are placed in series between the operating coil of the circuit breaker relay, closing the contact F, thus bus bars respectively.

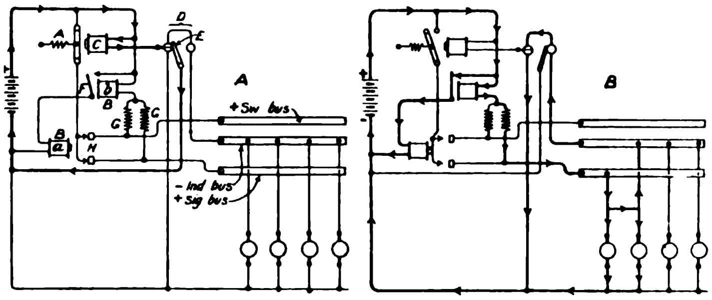


Fig. 13.

These resistances are so proportioned that the one in the signal circuit, while permitting sufficient current to flow to hold such signals as are "clear," will not permit enough to flow to clear a signal, and the one in the switch circuit will not permit enough current to flow to operate a switch.

The opening of the circuit breaker causes the current to flow through these resistances in series with the operating coils of the circuit breaker relay, closing the contact F, thus throwing the main coil directly across the terminals of the battery and opening the main circuit.

It will be seen that any current flowing through the resistances G, whether holding signals "clear," tending to operate a switch, or on account of a cross with an operating wire of either class of functions, will continue to energise the operating coils of the circuit breaker relay, and that all such current must be cut off before the contact F will open and de-

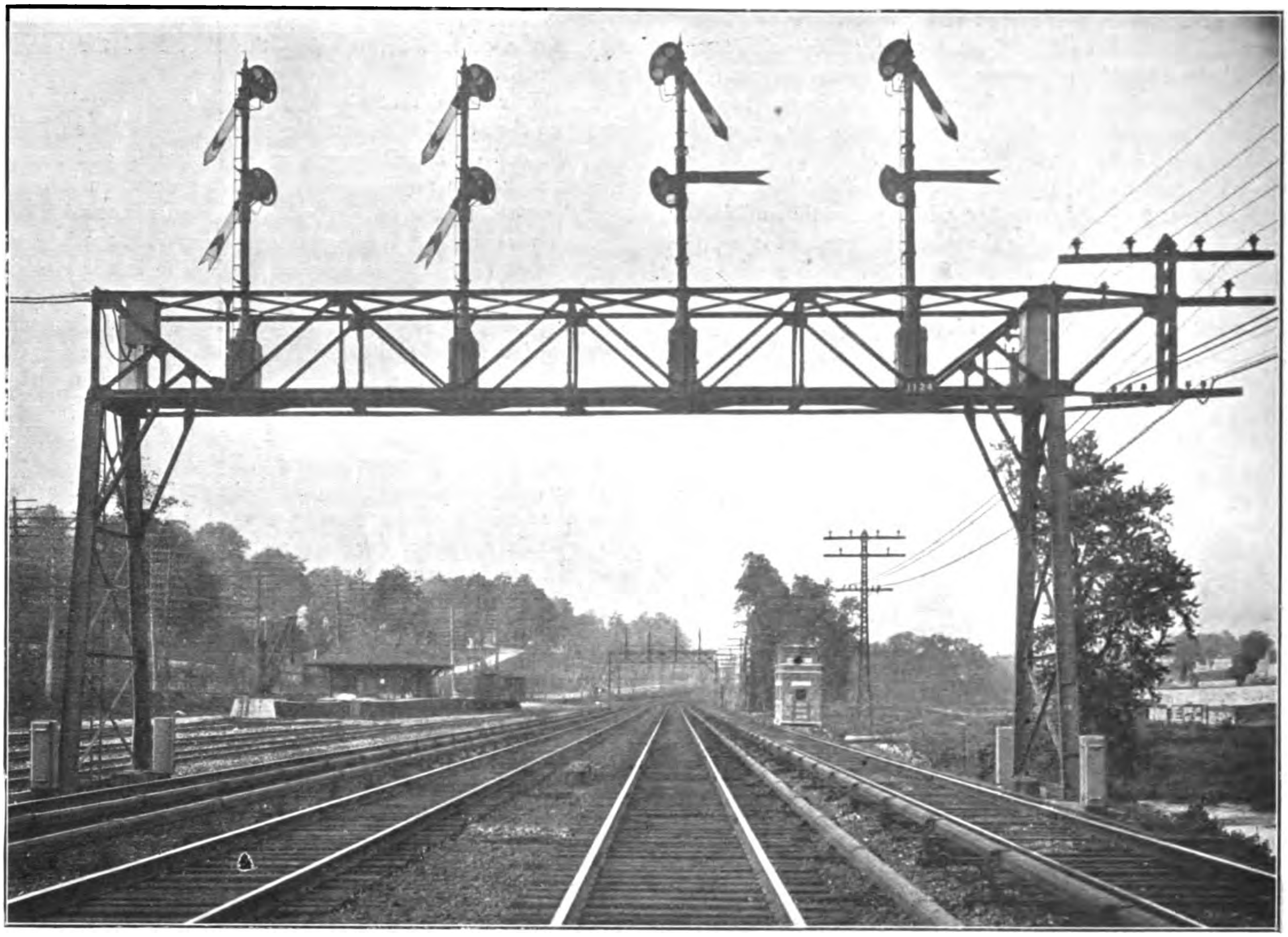


Fig. 14.

energise the main coil, closing the contact H and permitting the closing of the main circuit breaker.

When the circuit breaker opens while a signal is "clear," or while a switch is being thrown and before the completion of its stroke, it is necessary to return all signal levers to the normal position, and to put the switch levers in a central position (all controlling contacts open) before the operating coils of the circuit breaker relay will be de-energised, permitting the closing of the main circuit breaker.

If the cross cannot be quickly located and removed, the removal of the fuse in the control circuit of the function in trouble will permit of the continued operation of such other portions of the plant as are not prevented by the mechanical locking.

In addition to the above described apparatus and in order to facilitate the location of the particular functional wire which is in trouble, the interlocking machines are sometimes equipped (where the location warrants the additional expense) with polarised relays in each functional wire, the contacts of which are in series with that on the switchboard relay.

The transmission line, along with the power cable, is run in conduits through the thickly-populated portions, but, in the open, on lattice poles similar to that shown on the right of fig. 14. Where there are bridges of signals an extension has been made, as seen, to the framework of the bridge in order to carry the transmission lines. The signal line consists of No. 0 bare copper wire, and the underground line of No. 0 twin conductor lead-covered cable run in the ducts or iron pipes as required.

Automatic signals are operated by a current of 55 volts, which is reduced from 2,200 volts by transformers, marked L.T. in fig. 25, fixed in the transmission line or on the signal bridges.

The line transformers are connected to the aerial lines by plug cut-outs, so designed that a transformer may be disconnected without danger. They are connected to the cable lines by combined fuse and junction boxes as shown in fig. 15. The cartridge fuses are supported on porcelain insulators and mounted in separate slate compartments, and the cables terminate on binding posts, so that either cable may be disconnected without disturbing its neighbour.

Fig. 16 shows the housing with a junction box on the right and a line transformer on the left. A ground shield, connected to the transformer case, is provided between the primary and secondary windings. The case is in turn grounded to the lattice pole by a B. and S. gauge copper wire, held in place by a channel pin.

"Track-Circuits" are, of course, employed, the voltage power of which depends on the length of the circuits and varies from ½ volt for circuits of 200ft. to 8 volts for circuits of 5,000ft. The reduction from 55 volts is made by track transformers, fig. 17 and TT, fig. 25, which are wound for a primary voltage of 55, a track secondary voltage—variable

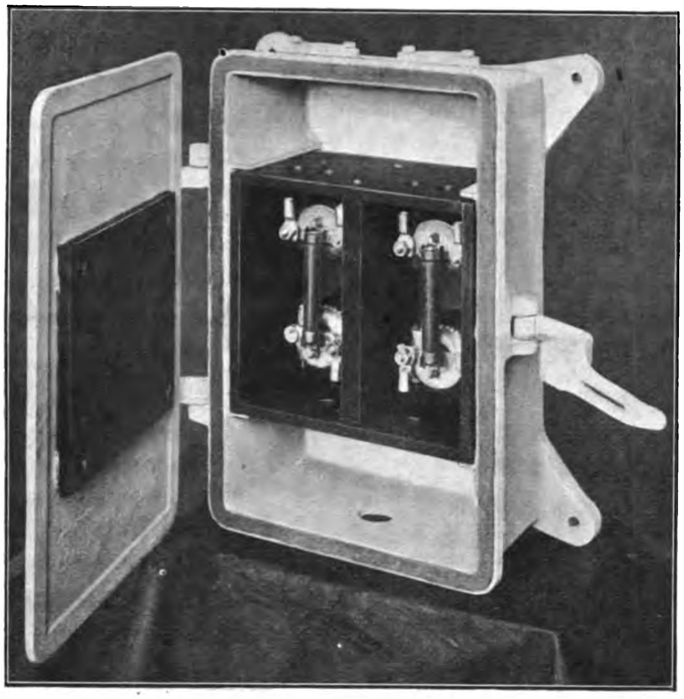


Fig 15.

by means of taps—from 2 to 6, and a relay secondary giving 2 volts. The transformers have a closed magnetic circuit and are provided with slate terminal boards having a binding post for each terminal or tap. They are oil cooled, placed in suitably casketed iron cases and provided with six outgoing flexible leads as shown in the lower part of the larger open case in fig. 18. Above the track transformer, in a wooden box, is the track relay, and below is a slate terminal board. Above the cases containing the track transformer

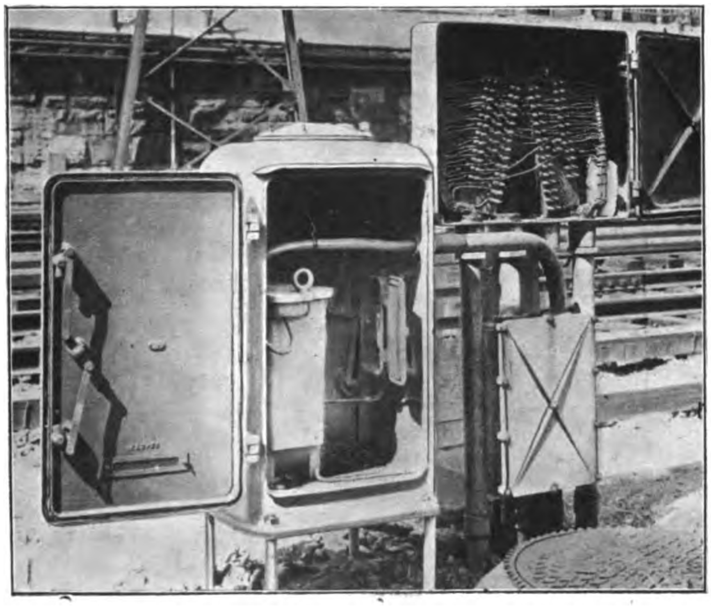


Fig. 16.

and relay is another holding the cast-iron resistance G, fig. 25, grids for limiting the flow of current from the track transformer when a train is standing on the transformer end of the circuit.

Fig. 19 is a view of a relay box. The fuses, lightning arrester and terminal, are at the top and the relays on the shelves beneath.

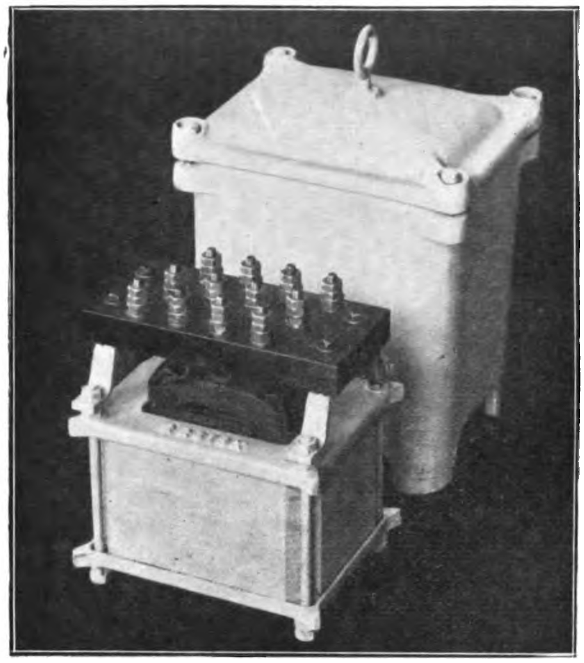


Fig. 17.

Except in the terminals and on short sections at the interlocking plants both rails of each track are used for the return traction current which is direct current. The current for the "Track-Circuits" is alternating, but by the use of the system designed by Mr. S. Marsh Young, of the General Railway Signal Company, the "Track-Circuits" are pro-

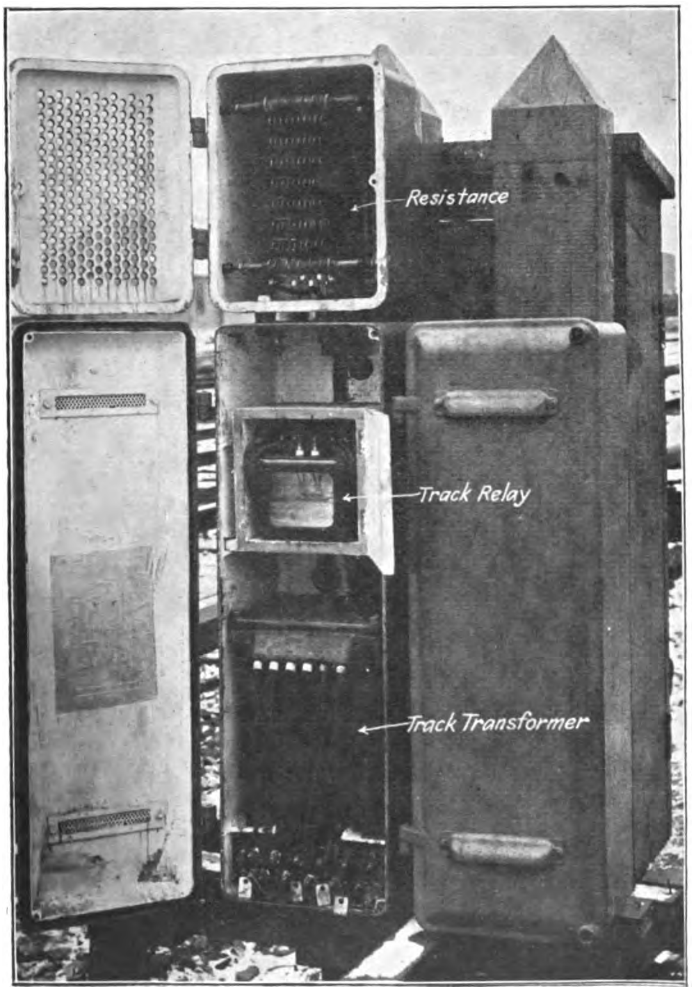


Fig. 18.

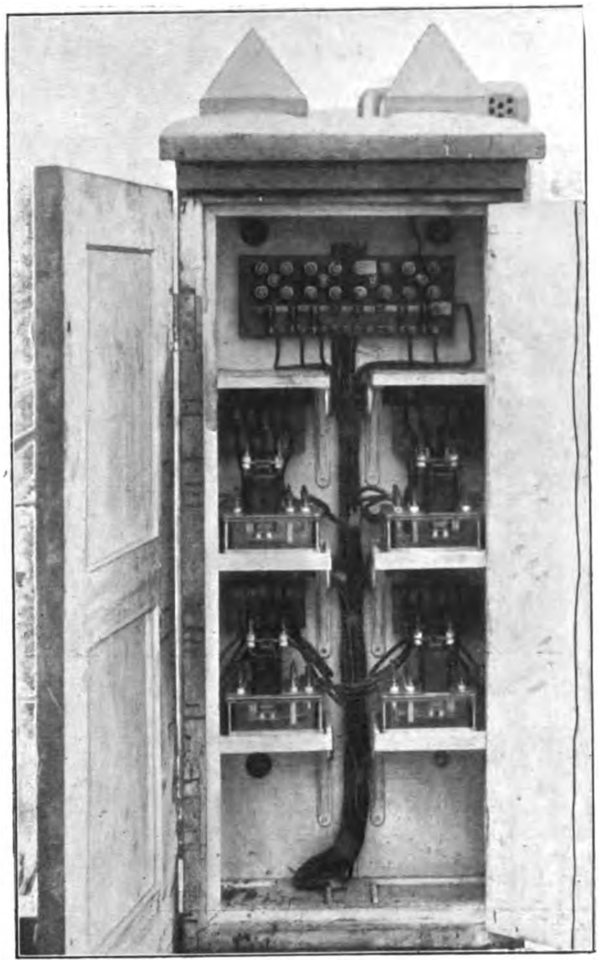


Fig. 19.

vided with reactance bonds which permit the free passage of the direct propulsion current through both the running rails but will impede the signal alternating current.

Fig. 20 illustrates the reactance bonds with and without their case. Each bond is wound with eight turns of copper having a sectional area of one square inch, with a continuous carrying capacity per track of 5,000 amperes, a short time overload of 10,000 amperes, and an unbalancing capacity of over 1,000 amperes—the latter without varying the reactance over 5 per cent. The apparent resistance of the bond to alternating current is approximately 5/100 of an ohm.

The bonds are provided with an air gap in the magnetic circuit to limit the effect of unbalancing as above, the gap being adjustable so that the reactance or unbalancing capacity can be varied as required to suit local conditions. A connecting chamber is provided in the case between the coils in which all coil ends terminate and where all connections to the rails, transformers, relays and cross bonds are made and then concealed by a suitable cover.

Fig. 21 gives details of the wiring between the reactance bonds and the rails, from which it will be seen that each reactance bond is connected to the two rails on each side of the insulated joints.

The track relays, P, fig. 25, are of the induction motor type with two field coils. One coil is energised by the 50 volt signal operating current through a special winding on the track transformer, which gives the greater part of the energy required to magnetise the fields and armature. The other coil is energised by the current from the track rails and it need only be strong enough to give sufficient magnetism to rotate the armature. This revolves through an angle of 720 degrees, during which movement the contacts are separated through 360 degrees and made up through 360 degrees, so giving a good rubbing contact. Especially hard carbon is used for the moving point of contact, whilst the fixed part is of platinum. As the controlled current is an alternating one, there is little sparking, although currents of from ⅛ to ¼ horse power are used.

In future work the track relays will be modified and equipped with a number of contacts so as to dispense with the secondary relays, S, fig. 25. The new form are illustrated by figs. 22, 23, the former being a front view and the latter a rear view.

The various moving contacts are mounted on a horizontal wooden bar, to which motion is imparted by means of a small two phase induction motor. One phase is connected to the rails and the other to the track transformer as shown at P, fig. 25. Of the energy in the two relay windings that supplied by the transformer direct is by far the greater. This requires but a small amount of energy from the track to give positive action on the contacts and, as a result, comparatively long "Track-Circuits" can be operated by a minimum of energy. The relay is inherently immune to the effects of alternating traction current by employing a distinctively dif-

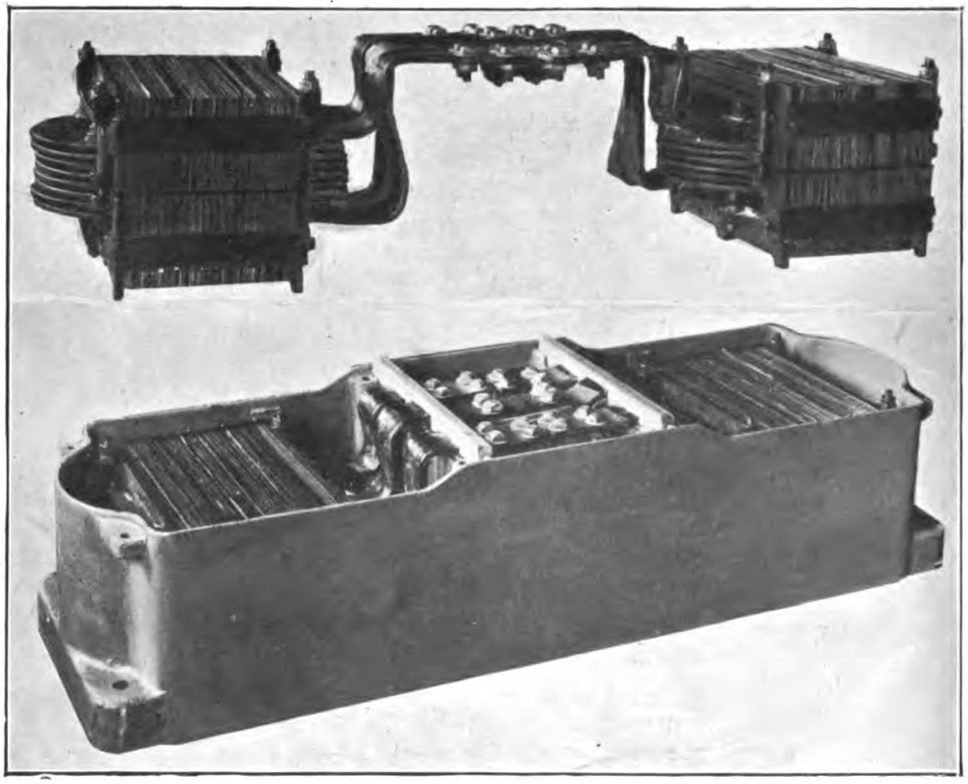


Fig. 20.—Double Reactance Bonds.

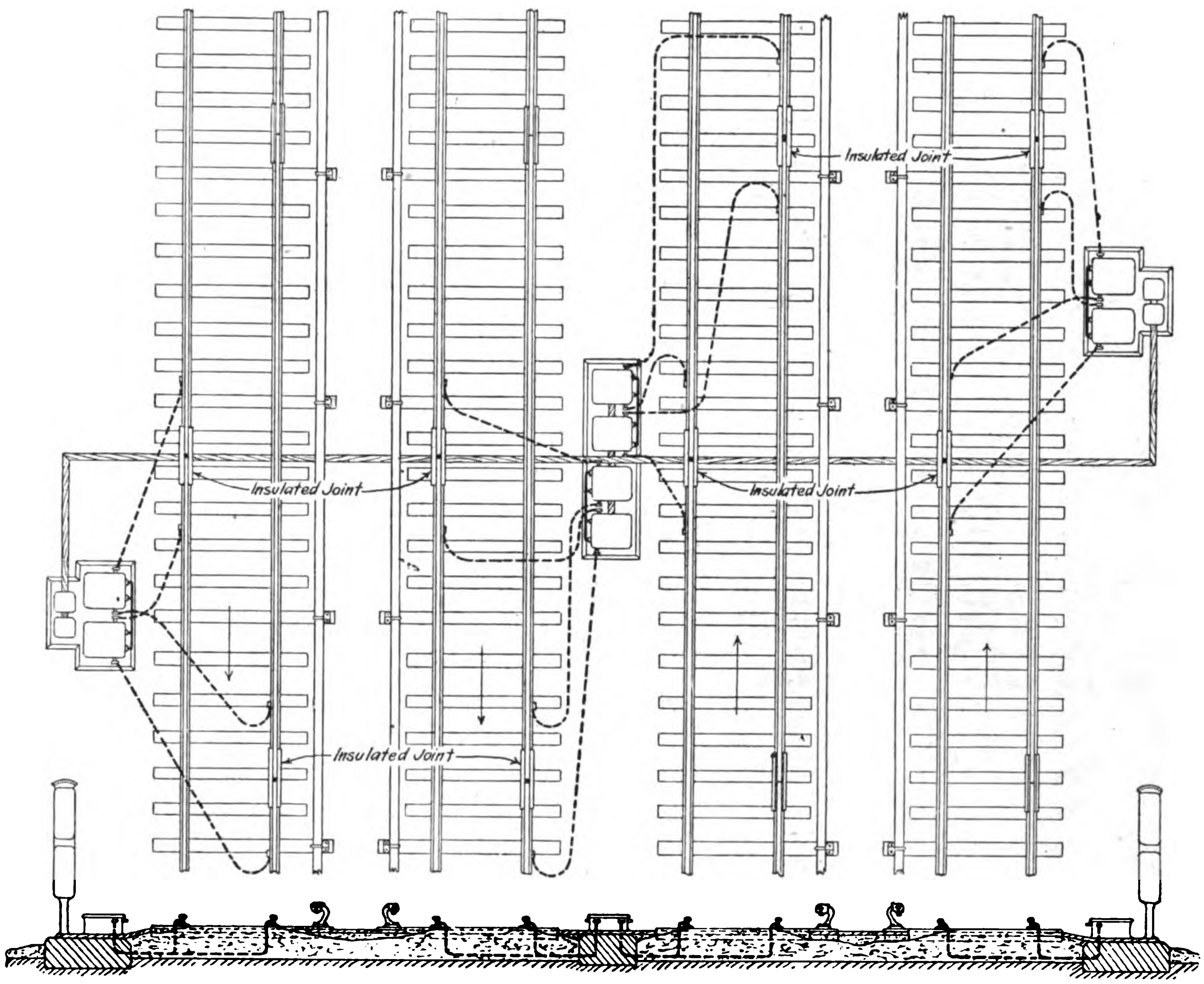


Fig. 21.

ferent frequency for signalling.

In deciding on the positions of the automatic signals regard was had to the braking distance of the trains. Where only a speed of 45m. p.h. is possible the average length of the section is 1,200ft.; for speeds between 45 and 60m. p.h. the length is 2,500ft. For higher speeds the average length is about 3,200ft. No stop signal can be lowered unless not only the section immediately in advance be clear but the succeeding one. The lowering of a stop signal therefore indicates two clear sections, and the arrangement provides an "overlap" of a full section. Distant signals are used. In the writer's opinion the three-position signal would have

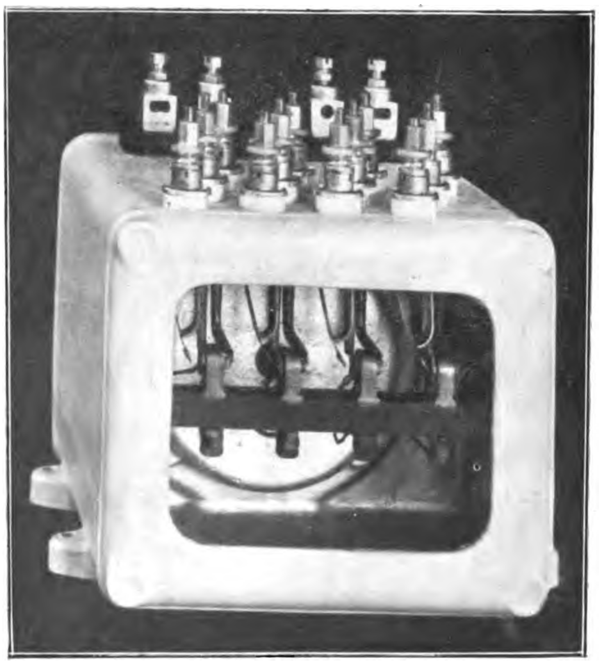


Fig. 22.

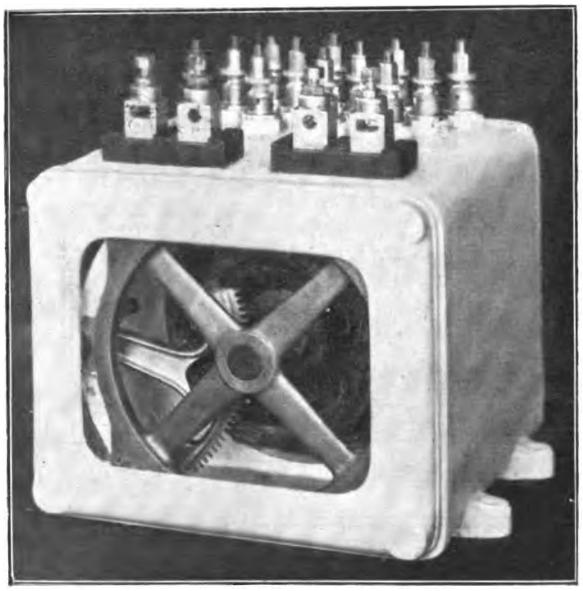


Fig 23.

been better for some reasons, as it would have reduced the number of arms and given the drivers fewer signals to read.

The copper connections from the reactance bonds to the rails after leaving the bond terminals go downwards and underground to the rails where, after passing for a short distance above ground to insure flexibility, they are connected to the rails. This leaves the space between the sleepers and rails free from obstruction.

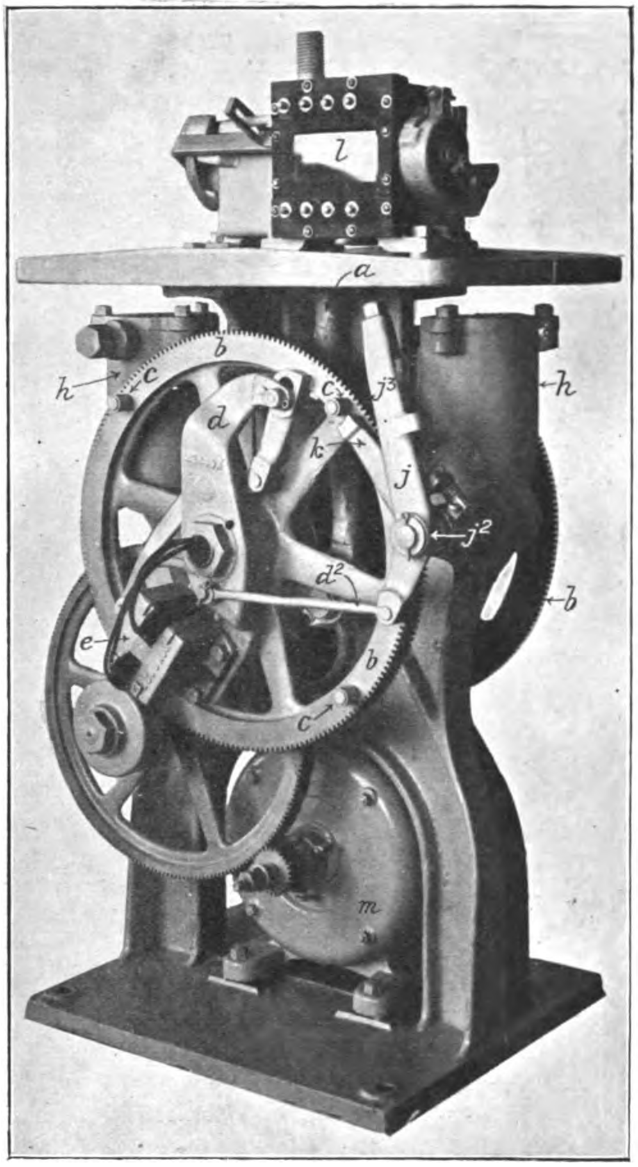


Fig. 24.

The bond connections to rails consist of two 500,000 circular mill flexible cables in multiple. The coils are immersed in transformer oil.

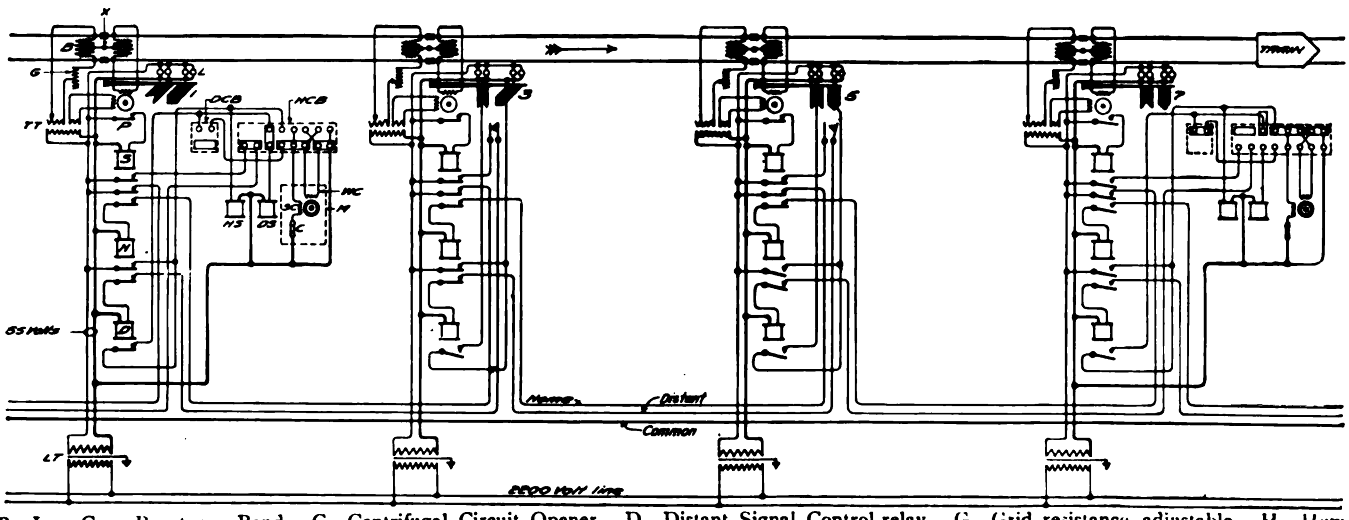
The reactance bonds are shown at B in fig. 25.

The mechanism for the automatic signal is illustrated by fig. 24, which represents that for a two-arm stop and distant signal, the upright rod for one of which is *a*. A gear wheel *b* is provided for each signal, driven through suitable gearing by the motor *m*. On the gear wheel *b* are pins *c* which come against the slot lever *d*. When the magnet *e* is energised the lever *d* is rigid and can be turned. The wheel *b* is carried on a shaft, and outside the wheel *b* is carried the slot lever and inside are two arms. To one is coupled the upright rod *a*, and when the signal rod falls the other comes up against the buffer of the dash-pot *h*. When the magnet is de-energised, after the signal has been lowered, as when the train passes the signal or the section is otherwise fouled, the slot lever *d* falls away from the pin *c* and the signal goes to danger by its own weight.

The accurate movement of the arm is determined by the stop arm *j* which is coupled to the slot arm *d* by the rod d^2. The stop arm is centred at j^2 and it turns to the left as the arm is lowered until the opening j^3 comes in line with the pins *c* and so stops the wheel *b* at the right moment. When the magnet *e* is de-energised the stop arm *j* falls to normal, and then the pawl *k*, also centred on the same pin as j^2, prevents the wheel *b* running in the opposite direction.

The distant signal is operated similarly but by the motor revolving in the opposite direction. This is governed, in part, by the circuit breakers on the upright rod, operated by a switch in the dust-proof case *l*, and by driving and holding clutches, which are each attracted as required.

The arm is cleared in two seconds, and on account of the heavy spectacle there is an upward thrust of over 200 pounds. The mechanism is operated by a ¼ H.P. single phase induction motor having starting and working coils as shown at



B—Iron Core Reactance Bond. C—Centrifugal Circuit Opener. D—Distant Signal Control relay. G—Grid resistance, adjustable. H—Home Signal Control relay. L—Signal Lights. M—Single Phase Induction Motor. P—Poly Phase Track relay. S—Secondary Track relay. DCB—Distant Circuit Breaker. HCB—Home Circuit Breaker. DS—Distant Slot Coil. HS—Home Slot Coil. LT—Line Transformer, 2,200 to 50 volt. TT—Track Transformer. SC—Motor Starting Coil. WC—Motor Working Coil. X—Cross Bond Connection.

Fig. 25.

S C and W C in fig. 25. An automatic centrifugal switch C, fig. 25, is used to open the starting coil as the motor speeds up.

A counter is fixed by the side of the circuit breaker *l* to record the work done by the signal. This affords useful information.

In the electrical connections energy for the home relay is obtained at the track relay immediately in the rear of the second home signal in advance of the relay in question, and is carried through all intervening track relays and switch boxes and returns to the transformer over the common wire. The distant contact relay receives its energy at the first home signal in advance of it, the control wire being taken through a normally closed contact on the home circuit breaker at that signal, over the line wire, through a front contact on the home relay at the signal location and then over the common wire to the transformer.

Fig. 25 shows a complete typical block signal circuit, four sets of signals being illustrated to show all the circuit combinations from "clear" to "stop"—the signals are on the "Normal-clear" system. In connection with signals 1 and 7, the internal connections of the signal mechanisms are shown—signal 1 at "clear" and signal 7 at "stop." To avoid confusion the mechanism wiring for signals 3 and 5 are not shown, the control wires running direct to the arms, it being understood that when current is applied to a control wire, the arm in question will "clear."

The "Track-Circuits" and various devices having been described and the illustration lettered to show the names of the devices, the operation of these circuits will be self-evident without further comment.

An interesting feature of the work on the Electric Zone is that the tie-plates at the switches are cut and have a 3in. gap between the two parts instead of having a fibre insulated joint for "Track-Circuit" purposes.

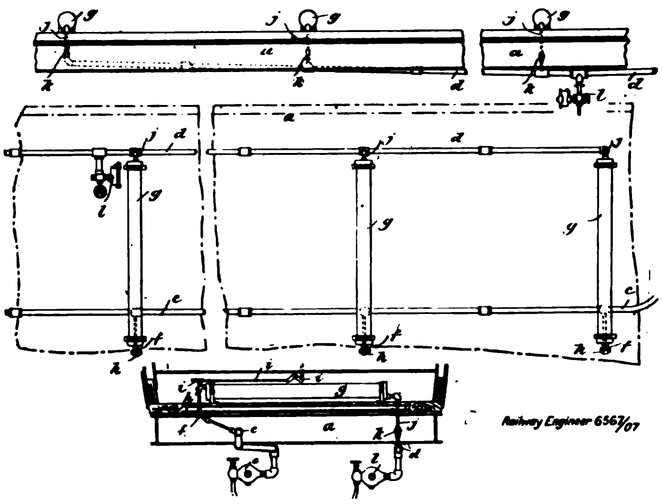
The writer is indebted to Mr. W. J. Wilgus, formerly Vice-President of the New York Central System, Captain Azel Ames, Jr., the Signal Engineer, and also the General Railway Signal Company for the drawings, photographs and data from which this article has been prepared.

Recent Patents relating to Railways.

These abridgements of recently published specifications are specially compiled for this Review by Messrs Wheatley and Mackenzie, Chartered Patent Agents, 40, Chancery Lane, W.C., from whom copies of the specifications can be obtained at an uniform price of 8*d*. each.

Warming Apparatus for Carriages. *6,576. 19th March, 1907. A. G. Wild, 10, Caxton Road, Sheffield.*

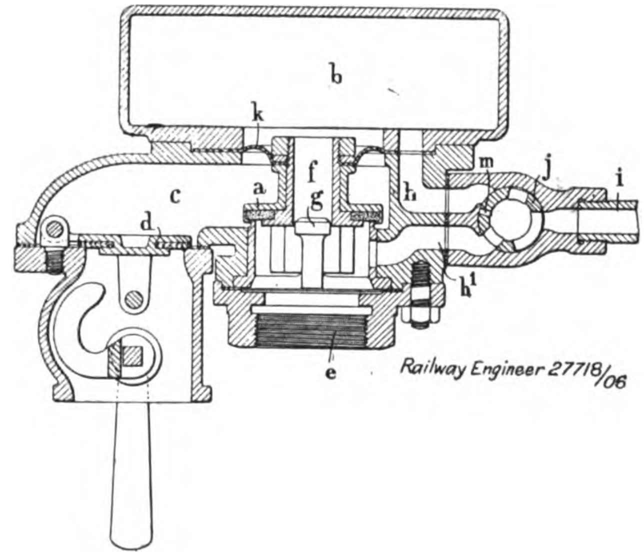
This invention is intended to provide a cheap and effective method of disposing of the condensation water of steam warming apparatus operated from the carriages. With the above object the steam heater *g* in each coach is coupled to a continuous drain pipe *d*. The steam pipe *c* of each coach communicates through tubes *j* with the steam heaters *g*, one or more of which are provided in each compartment, valves or regulators *h* being provided which are operated through a system of rods and levers, indicated generally by *i*, such system being arranged so as to permit of the ready manipulation of the regulator by the persons in the compartments. To facilitate the escape of pressure in any heater which has been in operation and has been cut off and to enable the heat and pressure to be reduced a bye-pass opens to the air when the steam valve or regulator is closed. The opposite ends of the heaters *g* are provided with pipes *j* communicating with



the drain pipe *d*, suitable trap valves being provided at *k* so that the pasasge of steam through the drain pipe into such of the heaters *g* as are not in use is prevented. The drain pipe is arranged so that it inclines downwardly towards the centre of the coach and at its lowest point it is provided with a steam trap *l*. *(Accepted 12th September, 1907.)*

Vacuum Brake Apparatus. *27,718. 5th December, 1906. H. E. Gresham, Craven Iron Works, Salford, Lancaster.*

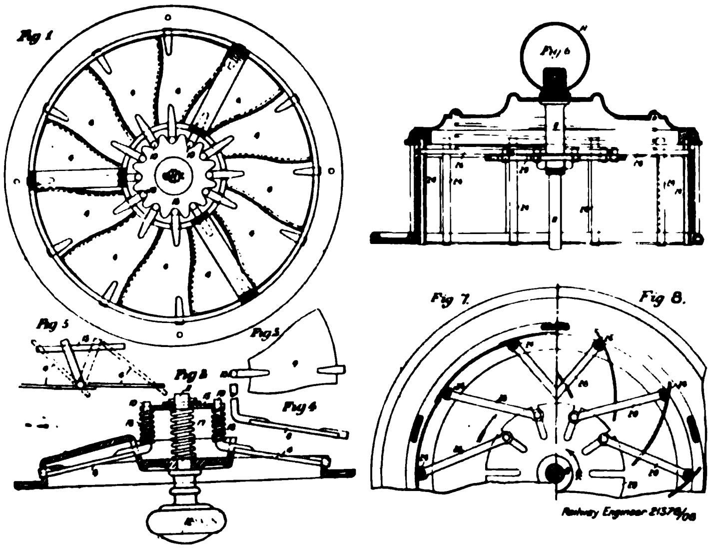
This apparatus is so constructed that it may be readily adjusted to give either a full application or a rapid graduated application of the brakes. For this purpose the valve *a*, controlling the supplementary inflow of air, is fitted between two chambers or compartments, *b*, *c*, formed in a suitable casing. The chamber or compartment, *b*, serves, when working on the graduated system, as a vacuum and balancing chamber, whilst *c* is an air chamber provided with an inwardly opening flap valve, *d*, whereby air is admitted direct from the atmosphere, when the diaphragm valve, *a*, is opened by a sudden inrush of air to the train pipe, *e*. The diaphragm valve, *a*, has an aperture, *f*, passing axially through it and a freely fitting plug or pin, *g*, fitted inside the valve casing, so that when the diaphragm valve, *a*, is on its seat the plug or pin, *g*,



almost closes the aperture, *f*, in the valve, leaving only a small area for the passage of air to or from the chamber, *b*. The vacuum and balancing chamber, *b*, is also connected, by way of the passage, *h*, with a pipe or conduit, *i*, communicating directly with the valve fitting of the brake cylinder or with the lower side of such cylinder. By means of a suitably

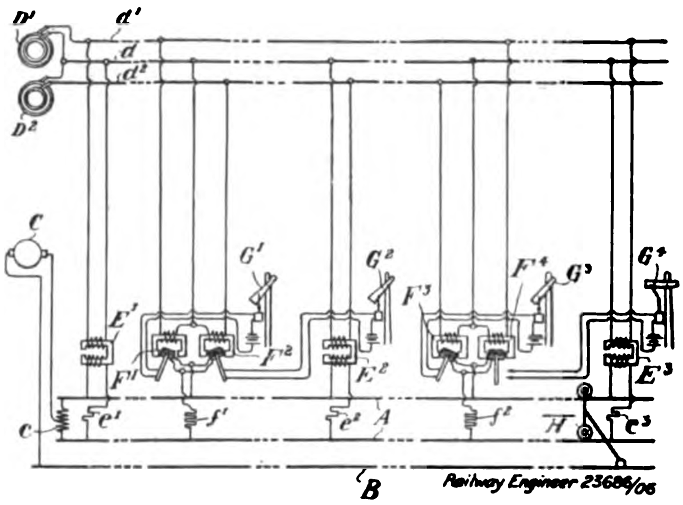
arranged valve or cock as *j*, the pipe or conduit, *i*, may either be connected with the chamber, *b*, for the direct working, or with the bye-pass, h^1, for the graduated system of working. On the exhaustion of the train pipe, *e*, by the action of the ejector in the usual manner, the vacuum and balancing chamber, *b*, and the brake cylinder are also exhausted, in the direct system of working, past the plug *g*; but in the graduated system of working, whilst the vacuum and balancing chamber, *b*, is exhausted past *g*, the brake cylinder is exhausted through the bye-pass, h^1. Both the ends of the diaphragm valve are thus exposed to the vacuum or reduced pressure, whilst within the air chamber, *c*, the atmosphere acts to close the diaphragm valve, *a*, and also, by pressure on the under surface of the diaphragm, *k*, to open the valve. The closing effect is, however, greater than the opening effect, and hence the valve is retained on its seating whilst the vacuum is maintained in the train pipe, *e*; for a part of the pressure acting on the under surface of the diaphragm is borne by the fixed casing to which the diaphragm is secured and thus does not tend to lift the valve. If now air be admitted to the train pipe, *e*, the pressure imposed on the lower end of the diaphragm valve, *a*, will cause the latter to be lifted from its seating and so put the air chamber, *c*, into communication with the train pipe, *e*. It follows that the flap valve, *d*, previously referred to, will be opened by the external pressure, permitting air to rush direct through the valve and thence to the brake cylinders. But the opening of the diaphragm valve produces a larger opening between the plug or partial closure piece, *g*, and the axial aperture, *f*, in the diaphragm valve, and air therefore rushes into the balancing chamber, *b*. When the valve or cock, *j*, in the pipe or conduit, *i*, allows communication between the latter and the chamber, *b*, the supplementary air passes from *b* directly to the brake cylinder. But when the said valve, *j*, shuts off such communication and is in the position shown in the drawing, the supplementary air can obtain access to the brake cylinder only by flowing through the bye-pass h^1, to the pipe or conduit, *i*. (*Accepted 3rd October, 1907.*)

Ventilators for Railway Carriages. *21,378. 27th September, 1906. H. J. Beresford, Cato Street Works, Cato Street, Vauxhall, Birmingham.*
This ventilator comprises an annular frame provided with a central boss and a series of overlapping radial flaps 4 mounted to turn about radial axes. Arms 10 at the inner ends of the



flaps are engaged by a toothed wheel 15 mounted on a central spindle 11 having an operating knob 12. When the spindle is turned in either direction the wheel turns the arms and opens or closes the flaps. Springs 17, 18 are arranged to impart a certain amount of stiffness to the movement of the spindle 11 and wheel 15 so that the positions of the flaps will be unaffected by vibration and they will remain at any desired inclination to the face of the ventilator. In another arrangement the flaps are mounted on vertical pivots 24 operatively connected by arms 26 with a notched plate 29 on the spindle 11. (*Accepted 27th September, 1907.*)

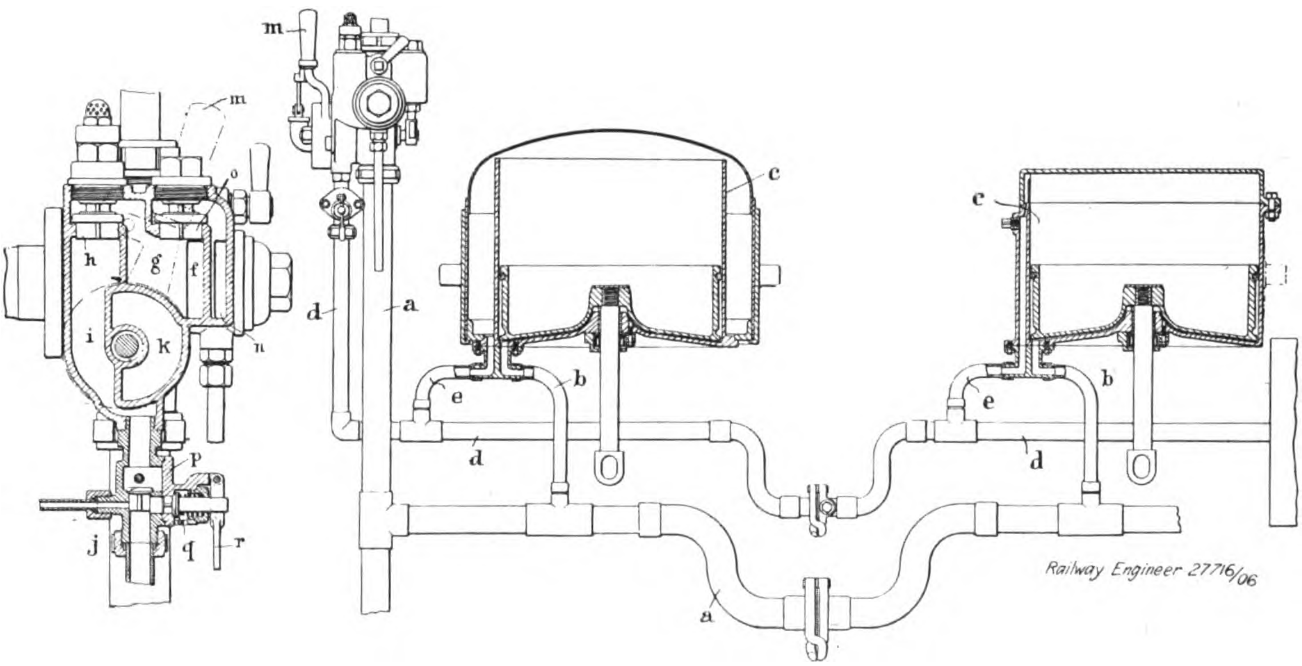
Block Signal System. *23,686. 24th October, 1906. The British Thomson-Houston Co., Ltd., 83, Cannon Street, London. (Communicated by The General Electric Co., Schenechady, New York, U.S.A.).*
One terminal of an electric current generator C is connected to a third rail B, and the other to the rails A through a differential choke-coil c. High-frequency alternators D^1 D^2, of different frequencies, supply the signal current through the line wires *d*, d^1 and d^2. Transformers E^1 and E^2, etc., supply current from these generators to the rails at intervals corresponding to the length of two blocks. Adjacent transformers E^1 and E^2 are connected to line-wires of different frequency. A small resistance e^1 may be inserted between the track rails and the transformer secondary to reduce the flow of power-current through the transformer. Two relays F^1 and F^2 are connected across the track rails midway between the transformers E^1 and E^2. A small resistance f^1 may be connected in series with the track-windings of the relays to



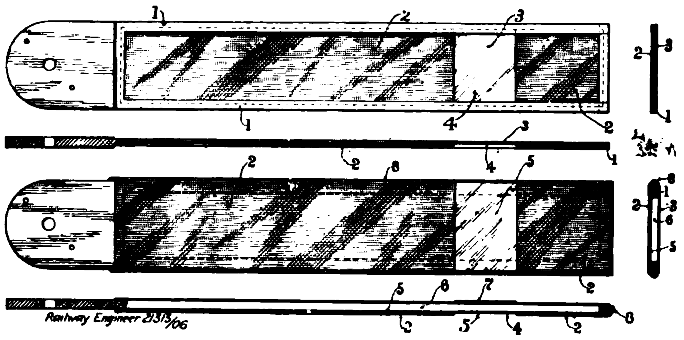
reduce the flow of power-current through them. The relays are each arranged to respond to only one frequency and for this purpose each relay is provided with a second winding supplied independently of the rails with a current of the frequency to which the relay is to respond. Since the transformers E^1 and E^2 are separated by a distance corresponding to the length of two blocks, the portion of track between transformer E^1 and relay F^1 comprises one block, and the portion between relay F^2 and transformer E^2 comprises another block. Consequently one signal G^1 is placed near the relays, and is controlled by the relay F^1. The second signal G^2 is placed near transformer E^2, and is controlled by relay F^2. Transformer E^2 supplies the current for two blocks, the relay F^3 being energised by this transformer and controlling the signal G^3. It will be noted that the transformer E^2 which is connected to the same line-wires as transformer E^1 may be reversely connected, as shown in the drawing, so as to eliminate all possibility of relay F^1 being operated by a current from transformer E^3, or relay F^4 being operated from transformer E^1. The operation of the system is as follows:—
If a train is in the position indicated by H moving in the direction of the arrow, the rails of the block between transformer E^3 and relay F^4 are short-circuited, so that relay F^4 drops its armature, letting signal G^4 go to danger. Relay F^3 is not affected by a train near the entrance end of the preceding block, since the rails offer a high impedance to the high-frequency alternating current employed. Consequently relay F^3 does not drop its armature until the train H has reached a point so near the relay that the rail-length between the relay and the train is of sufficiently low impedance to shunt the relay effectively. This distance depends upon the regulation of

the transformer supplying the relay, the frequency of the signal-current, and the design of the relay. By the time that the train has reached the relay F^3, the relay will be shunted, putting the G^3 signal at danger. After the train has proceeded a certain distance into the next block the relay F^4 will pick up its armature, clearing signal G^4. Shortly before the train reaches the transformer E^2 it will act to pull down the voltage supplied by the transformer to the track, so as to cause relay F^2 to drop its armature and put signal G^2 at danger. Then after the train has passed transformer E^2 a certain distance, signal G^3 will clear. *(Accepted 12th September, 1907.)*

Vacuum Brake. *27,716. 5th December, 1906. H. E. Gresham, Craven Iron Works, Salford.*
The object of this invention is to provide such a combination of compound ejector with vacuum brake cylinders as will enable the usual automatic ball valves to be dispensed with. The continuously working nozzles of the ejector exhaust the contents of the pipe *d* and the upper portions of the brake cylinders by way of the port *f*, chamber *g*, valve *h*, chamber *i* and valve *j*, and also of the pipe *a* and the lower portions of the brake cylinders by way of the port *f*, chamber *g*, valve *h* and chambers *i* and *k*. Communication between the chambers *i* and *k* is controlled by the air valve operated by the hand lever *m* in the usual manner. When it is desired to apply the brakes air is admitted to the train pipes *a* by the air valve operated by the hand lever *m*, and at the same time communication is cut off between the chambers *i* and *k* in the usual manner. When it is desired to release the brakes quickly after an application of the same, the second set or intermittently working nozzles of the ejector are brought into action along with the continuously working nozzles and communication is again established between the chambers *i* and *k*. The pipes *a* and *d* and their connections are then exhausted, by way of the ports *n* and *f* and valves *o* and *h*. After the whole system has been brought into a vacuous condition, the second set or intermittently working nozzles are put out of action and the vacuum is maintained by the continuously working nozzles. *(Accepted 19th September, 1907.)*



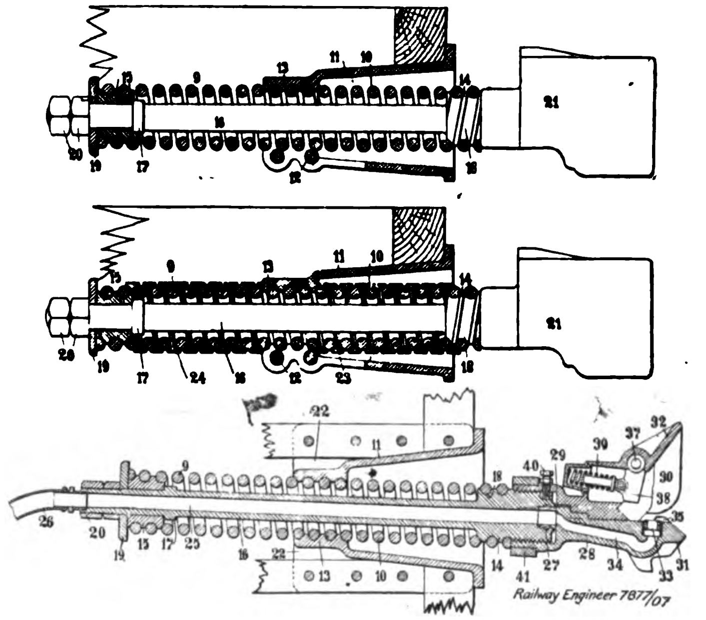
Semaphore Signals. *21,313. 26th September, 1906. W. Bleakley, 23, Bainbrigge Road, Headingley, Leeds.*
A signal arm that does not require to be painted is, according to this invention, composed of an open frame carrying or supporting a diaphragm made of a sheet or sheets of xylonite or celluloid, which diaphragm is adapted to permit the penetration of the light rays from the side opposite to that on which it may be viewed, and presenting a surface to which soot or other foreign matter is not readily adherent. The diaphragm is preferably composed of two adjacent sheets of xylonite or celluloid, one sheet being white and translucent, and the other sheet red and transparent, and portions of either sheet may be cut away so as to expose to view portions of the other sheet, and such cut-away portions of the coloured



sheet may represent the usual white patch and any distinguishing letters or numbers required to be exhibited; or a composite sheet may be made of coloured and uncoloured xylonite or celluloid and used to form such arms, portions being cut away from either side to form the desired openings. The signal-arm—which may be of the usual shape and which may carry the "spectacle"—is pivoted and operated in like manner to that of the ordinary signal-arm. *(Accepted 26th September, 1907.)*

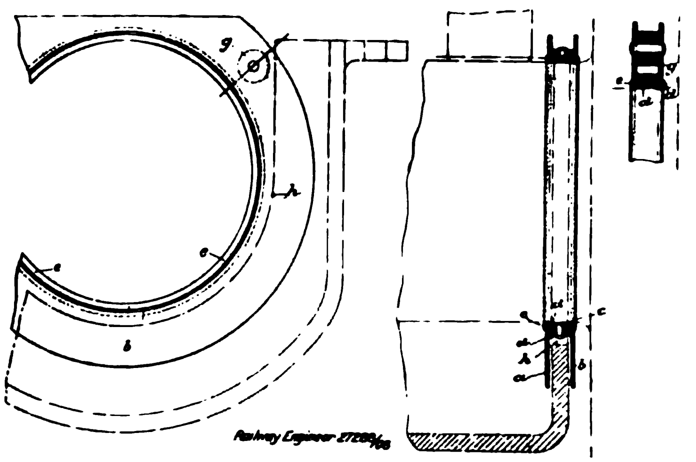
Draw Gear. *7,877. 4th April, 1907. Date claimed under Patents Act, 1901, 12th April, 1906. G. Westinghouse, Westinghouse Building, Pittsburg, U.S.A.*
This gear comprises a single helical spring secured to the vehicle by a casing 11 which engages the spring at a point intermediate its ends, thus forming two spring sections 9, 10 which are secured at the free ends to heads or bosses 14, 15 on opposite ends of the draw bar 16. Any suitable form of casing for supporting the spring may be employed, but, as shown, this casing 11 comprises a split end portion 13 having

formed in the inner surface thereof a helical groove, into which the spring is adapted to be screwed, and bolts 12 for clamping the same when properly adjusted. The casing also has an outwardly flaring portion surrounding the spring section 10 for permitting a certain lateral play of the coupler, and may also be provided with flanges 22, as indicated in fig 3, for securing the same to the car frame. Either draft or buffing strains will be transmitted through both sections of the spring, subjecting one section to compression and the other section to tension, thereby securing double spring capacity under either strain. This spring capacity may be increased, if desired, by the addition of friction springs 23 and 24, as shown in fig. 2, the coils of which are mounted between the coils of the draft spring sections 10 and 9, and are provided with frictional surfaces adapted to engage the surfaces of the coils of the draft spring when the latter is subject to compression. According to the construction shown in figs. 3 and 4, the draw bar is tubular, having a passage 25 extending therethrough and connected at its outer end to an automatic coupler head 30, having a registering passage 31 leading to the gasket opening 33 in the face of the coupler for coupling a fluid pressure conduit, such as compressed air, through a train, a hose 26 being connected at the inner end of the draw bar. The automatic coupler head 30 has a latch or locking lever 38 pivoted on a vertical shaft 37, and normally pressed outward by a spring 39 for engaging a suitable bear-



ing surface on the outer side of the projecting portion 31 of a counterpart coupler after the vertical rib portions 31 have slipped past each other, and thereby firmly lock the two coupler heads together. An enlarged gathering hood 32 is provided for the purpose of obtaining an automatic engagement of the two parts of the coupler, even though these are laterally somewhat out of alignment, due to track curvature, or other reasons, and in order to facilitate the machining of the surfaces the coupler head is preferably formed in two longitudinal parts 28 and 29, which may be secured together by transverse bolts, as indicated. Another advantage of this divided arrangement is that, in case of breakage of the hood or other part, it is only necessary to renew one half of the coupler head. *(Accepted 3rd October, 1907.)*

Axle Boxes. *27,288. 30th November, 1906. A. Spencer, 77, Cannon Street, London.*
According to this invention the inner end of the axle box is plain or formed without the usual groove or recess for receiving the dust shield, and the dust shield comprises a ring of U or channel cross section into which extends the plain wall of the axle box around the hole therein, and the base of the U or channel section ring is furnished on its inner periphery with a packing ring of leather or the like that fits around the axle journal. The channel shaped ring is built up of two angle section metal rings *a* and *b* placed face to face one within



the other and secured together by rivets *c* passed through the two overlapping webs *d* of the rings. The packing ring *e* is of leather and is fixed to the compound metal ring by the same rivets *c* that secure the two parts of the ring together. *(Accepted 12th September, 1907.)*

COMPLETE SPECIFICATIONS ACCEPTED.

1906.

20169. Apparatus for operating the points of tramways. Hayes and Watson.
21313. Semaphore signals used on railways. Bleakley.
21375. Fishplates and chairs for the joints of railway rails. Marriott.
21378. Ventilators for the roofs of railway carriages, tramcars, and for other purposes. Beresford.
21801. Railway carriage and similar door fasteners. Gorst.
21869. Coupling devices for railway vehicles. Walkington.
23686. Signal systems for railways and the like. British Thomson-Houston Co.
23779. Railway wagons and like vehicles. Fox.
24533. Signalling apparatus for railways. Bevan.
27255. Automatic couplings for railway and the like vehicles. Legg.
27288. Axle-boxes. Spencer.
27716. Vacuum brake apparatus for railway and like vehicles. Gresham.
27718. Vacuum brake apparatus for railway and like vehicles. Gresham.
29153. Rail-sanding apparatus for tramway, railway, and the like vehicles. Mallins.

1907.

362. Means for locking and unlocking simultaneously the doors of railway carriages; also applicable for locking and unlocking other doors. Snowden.
938. Headlights for railway and tramway vehicles. Baylor.
1900. Signals on locomotive engines and the stopping of locomotive engines. Harbottle.
2053. Electrical apparatus for automatically indicating the positions of trains on railways. Trautmann, née Sprie.
2705. Railway signalling apparatus. Raven.
3461. Brake gear for railway wagons and like vehicles. Stepney and Thomson.
3646. Rail joint. Godsell.
5817. Automatic fog signal alarm controlled by distant signal lever in the signal cabin. Wootton and Wootton.
6576. Apparatus for warming railway carriages by steam. Wild.
7145. Chairs for tramway and like rails. Strong.
7877. Draft gear for vehicles. Westinghouse.
8103. Buffers of railway wagons and the like. Veater and Jones.
8928. Draw gear for railway and like vehicles. Pettigrew.
9005. Railway couplings. Garms.
9233. Paving for railway crossings. Gross.
10709. Electro-magnetic brakes for railway and other vehicles. Braun.
10919. "Tying" the permanent way rails of railways. Orange.
11034. Metallic railway cross ties and rail fastenings therefor. Moorhead.
11812. Wagons or trucks. Smith.
11843. Fishplate joints for railway rails, girders, and the like. Wilson.
13963. Composite railway ties. Chapman.
14079. Propulsion of trains, ships, and the like. Felton and Guilleaume-Lahmeyerwerke Akt, Ges.
15292. Railway and tramway points, switches and signals. Dodwell.
15946. Rail joints. Shaw.
16488. Signalling on railways. Nicholson.

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THE
Railway Engineer

VOLUME XXIX., No. 337. *FEBRUARY*, 1908.

Contents.

The Hon. W. Lowther has resigned the seat which he has held for 40 years on the Board of the L. and North Western R.

Mr. John Wm. Wilson, M.P., of the firm of Albright and Wilson, chemical manufacturers, Oldbury, near Birmingham, has been elected a director of the Great Western R. to fill the vacancy caused by the resignation of Mr. Alex. Hubbard.

Sir W. D. Pearson, Bart, M.P., has been elected a director of the Interoceanic R. of Mexico.

Mr. Stephen A. Pope, of the general manager's office, Great Western R., has been appointed commercial assistant to the superintendent of the line. Mr. Pope, among other duties, will as heretofore have charge of the Company's publicity arrangements.

Mr. Arthur Collinson, who left the North Eastern R. to become manager of the Met. District R., has returned to his old company and been appointed district superintendent at Middlesbrough in succession to **Mr. C. A. Lambert**, who has been appointed district superintendent at Hull in succession to **Mr. J. Wolton**, who some time back was appointed district goods manager at Darlington.

Mr. A. S. Taylor has been appointed district locomotive superintendent of the Midland R. at Carlisle; **Mr. T. Ryder**, at Brecon, and **Mr. W. I. Stevens** at Buxton.

Mr. John Wilson, district locomotive superintendent of the Great Eastern R. at Lynn has retired after 51 years' service on the railway.

Mr. James Holden, locomotive superintendent of the Great Eastern R., retired, as we announced in our issue last September he would do, at the end of the year, and was succeeded by his son, **Mr. Stephen Dewar Holden**, who for some time had been assistant locomotive superintendent. The directors in their half-yearly report most truly state that the shareholders are indebted to him "for 23 years of indefatigable and most valuable service."

Mr. James R. Annett retired from the position of chief signal superintendent of the L. and South Western R. at the end of last year. He is the son of the late Mr. James Annett, of the L., Brighton and S.C.R., whose name is known all over the world as the inventor of Annett's lock for controlling outlying sidings. He joined the L. and South Western R. in 1870, was for many years district signal superintendent for the central division at Eastleigh, and became chief signal superintendent in 1894, and subsequently removed to Wimbledon. He has been very popular amongst his fellow-officers and the staff, both of his own and other railways. He was one of the earliest members of the Conference of Railway Companies' Signal Superintendents, and was President in 1894. He has ingeniously solved many problems in signalling, and amongst the ideas associated with his name are his point rod coupling, wire compensator, route lock, screen for blinding the green spectacle, and the route indicating signal, all of which have been illustrated from time to time in this journal.

Mr. Arthur H. Johnson, M.I.C.E., has been appointed to succeed Mr. Annett, and will combine the supervision of the signal department with his former duties as telegraph superintendent. Mr. Johnson spent some years in America, and was subsequently signal and telegraph engineer to the New Zealand Government Rs. He returned to this country a few years ago, and entered the service of the L. and South Western R., and was appointed telegraph superintendent on the retirement of the late Mr. Goldstone.

Mr. T. A. Wilson, general manager of the Highland R., has been appointed chairman of the Scottish General Managers' Conference for 1908.

Mr. Thomas Cairns has been appointed Harbour Master of the North British R. Docks at Bo'ness. He has acted as deputy harbour master at Methil for about 9 years, and has been about 14 years in the service of the company.

Mr. Geo. Cunningham has retired from the position of district superintendent of the western division of the North British R. and he was recently, at the Faculty Hall, Glasgow, presented with a cheque enclosed in a silver case by Lord Provost Bilsland on behalf of a large number of gentlemen representative of the general travelling public of Glasgow and the West of Scotland.

WE regret to record the death on the 4th ultimo, at Stockport, at the age of 57, of **Mr. Henry Linaker**, the highly respected superintendent of the L. and North Western R. at Manchester and district.

Prussian State Railways, 1907.

THE Prussian Minister of Public Works has informed the Chamber that the loss on the working of the Prussian State railways during 1907 will amount to £5,000,000. This loss is put down to climatic conditions, and especially to the poor returns from the new tax on railway tickets.

*

Swiss Railways, 1907.

DURING 1907 the receipts of the Swiss Federal railways amounted to £5,683,053, or an excess of £2,056,612 over the expenditure. The receipts of the St. Gothard R. during 1907 were £413,400 in excess of the expenditure.

*

Theatre Cars.

THE first theatre-car was attached to the South Express leaving Paris on the 20th ultimo. The car consisted of a miniature theatre holding an audience of 80 persons, who took their seats when taking their railway tickets before starting. The French Press welcomes the innovation. It remains to be seen whether the idea will prove to be remunerative and worthy of beng extended.

*

Railway Construction in U.S.A. in 1907.

THERE was a slight falling-off in railway construction during 1907 in the United States. The total length of new lines amounted to 5,200 miles, as compared with 5,600 in 1906. Nevertheless these figures are in excess of the average for the last ten years, for from 1898 to 1907 the average length of new lines was 4,880 miles a year.

*

New Rolling Stock for Russian Railways.

THE orders for new rolling stock given by the Russian Government to the home makers for 1908 are smaller than they were for 1907, and even then they were regarded as being inadequate. While orders were given last year for 12,800 cars and trucks and for 729 locomotives, the orders for 1908 amount only to 10,500 and 558 respectively.

*

Mileage Protected by Signals in America.

FROM the annual report of the Interstate Commerce Commission for the year ending June 30th, 1906—the last published —it is stated that there are 222,340 route miles of railway in America, of which 20,981 consist of two or more lines and 201,359, or over 90 per cent., are single. According to the return annually presented by *The Railway Age* the mileage protected by signals at the end of 1907 was as follows :- -

	Lines, Two or more.	Single.
By Automatic Signals ...	6,770	4,703
,, Lock-and-Block	869	2,621
,, Ordinary Block	7,713	36,675
,, Electrical Train Staff ...	—	247
Total	15,352	44,246
	(73 %)	(22 %)

*

New Dock at Methil, North British R.

THE construction of the new Dock at Methil, authorised by the North British Railway Act, 1907, is about to be commenced. The dock will be about 15 acres in extent, with a depth of water of 32ft. The work will include protection sea walls about 1,700 yards long, and an entrance channel about 950 yards long. The existing docks owned by the North British R. at Methil are 11½ acres in extent.

*

Wages for Paupers.

THE petition of the Lambeth paupers to be paid wages for their work is one which will immediately interest the ordinary shareholders of the L. and South Western R. Co., as in the event of the proposition, which is seriously supported by Socialists, ever fructifying, they, as the largest ratepayers in Lambeth, would have to pay the said " wages " out of their dividends.

The Leeds Forge Co.

THIS Company has opened a London office at Caxton House, Westminster, and has appointed Mr. H. Kelway-Bamber, whose retirement from the position of carriage and wagon superintendent of the East Indian R. we noted in our last issue, to be their London manager.

*

Railway Pictorial Post-Cards.

THE L. and North Western R. Co. have issued six more sets (Nos. 49-54) of beautiful coloured picture post-cards. Each packet contains six cards and is sold at the low price of *2d.* Two of the new sets are devoted to Kentish and other South Coast Watering Places which are served by the North Western through services from the North and Midland districts. Two other very pretty sets illustrate the beauty spots of the Warwick district and Shrewsbury, and another set (No. 51), devoted to the 2.30 Birmingham 2-hours Express, is somewhat of a novelty in that the cards are joined together and when opened out show the complete train. The cards tear off at the end of the tender and between each carriage. Besides showing the exterior of the carriages in colour a small view of the interior is also given underneath. Upwards of 8 millions of these post-cards have now been sold, and they must have provided the Company with a magnificent and profitable advertisement. And the complete series not only illustrates the progressive growth of railways, but familiarises the public with the best scenery and buildings in the country.

*

Bordeaux Maritime Exhibition, 1907.

THIS Exhibition, which was held in the summer of last year, was a great success. It was visited by the Institution of Naval Architects for their summer meetings, and there were many expressions of satisfaction from the members. The list of awards has now been issued, and amongst the successful exhibitors are Messrs. Wailes, Dove and Co. (1906), Ltd., of Newcastle-on-Tyne, who have been awarded gold medal and diploma for their exhibit of models of ship and iron buildings coated with their patent "Bitumastic" specialities. Messrs. Wailes, Dove and Co. also gained a gold medal at the Milan International Exhibition for the excellence of their specialities.

*

Ferro-Concrete Railway Bridge Construction.

AMONG recent contracts which have been settled for new bridges on the Mouchel system of ferro-concrete, one of the most important is for a railway bridge designed by Mr. W. Armstrong, M.Inst.C.E., New Works Engineer of the Great Western R., to carry main line traffic over Victoria Street, Bristol. As the first structure authorised in this country for such a purpose this bridge is of especial interest. It is also interesting to note that in connection with an extension of the Great Western R. near Avonmouth Docks a new railway bridge, several culverts, and foundations for three bridges, all in ferro-concrete, are about to be constructed.

In Leeds the North Eastern R. are about to build from the designs of Mr. W. J. Cudworth, M.Inst.C.E., a ferro-concrete railway bridge, and some viaduct work of similar character is under construction in the same city.

*

Trans-Andine Route, South America.

CABLE information has been received from Buenos Ayres to the effect that the Trans-Andine Passes are now open for coach traffic. The journey between Buenos Ayres and Valparaiso may therefore be made (entirely by rail except for four hours' coach) in about three days from ocean to ocean.

*

Electric Traction on the Midland Railway.

A TRIAL run was made on the 19th ultimo over the electrified section of the Midland R. between Heysham and Torrisholme Junction. The trial was quite successful and is interesting

mainly because it is the first time that a train has been run in this country by the single-phase system.

*

"Perfection Glazing."

MESSRS. HELLIWELL AND CO., LTD., are supplying their patent "Perfection" glazing for the new carriage sheds at Crewe (L. and N.W.R.), the passenger station at Millom (Furness R.), and the L.C.C. sub-stations at Islington, Hackney, Holloway, Upper Clapton and Stockwell. They have also a large export order for Brazil.

*

Light Railway Orders.

THE Board of Trade have recently confirmed the undermentioned Orders made by the Light Railway Commissioners :—

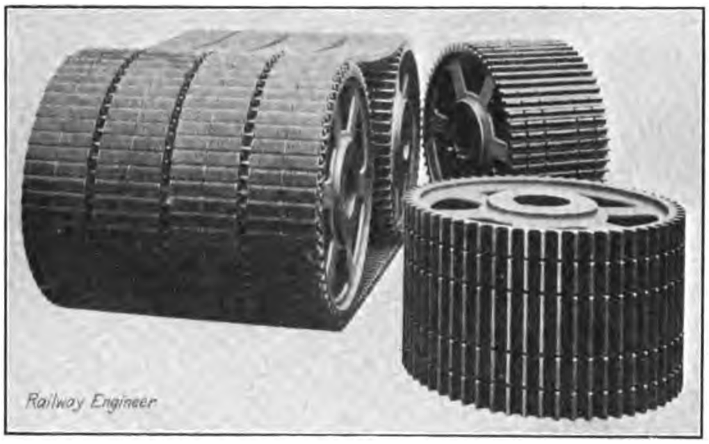
(1) *Cromarty and Dingwall Light Railway* (Extension of Time, Deviation and Amendment) Order, 1907, reviving the powers granted and extending the period limited by the Cromarty and Dingwall Light Railway Order, 1902, for the compulsory purchase of lands and extending the period limited by that Order for the completion of the railway and works by that Order authorised, and authorising a deviation of part of the said railway, and the compulsory purchase of certain lands for the purposes of the said railway and works.

(2) *East and West Yorkshire Union Light Railway* (Borrowing Powers) Order, 1907, authorising the East and West Yorkshire Union Railways Company to exercise further borrowing powers.

*

Large Morse Chain Drives.

THE Westinghouse Brake Company, of 82, York Road, King's Cross, inform us that they have recently executed an order for what is probably the biggest chain power transmission yet attempted, that is to say, three Morse silent high speed rocker-joint drives complete, each to transmit 500 horse-power. These drives were ordered by an engine works



in Russia, Government of Moscow, which already had a 280-horse-power drive in satisfactory operation. The accompanying illustration gives a good idea of the appearance of these large drives, of which the following are further particulars: Diameter of wheels, 37·78in.; face width, 22in.; teeth, 2in. pitch by 10in. wide. Two chains running side by side over one set of wheels.

*

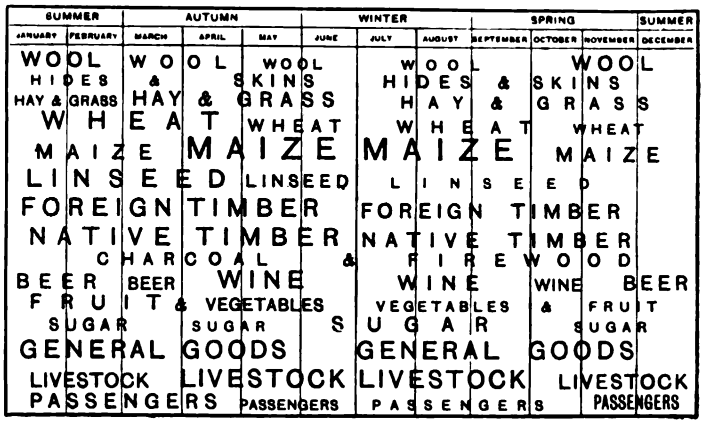
"Socialisation of Railways."

THE Labour Party at the Conference at Hull last month merged itself with the Socialists and decided that its definite object was the "socialisation of the means of production, distribution and exchange" to be controlled in the "interests of the entire community" and the "complete emancipation of Labour from the domination of Capitalism and Landlordism." One of our financial contemporaries estimates that £1,603,449,476 Government 2½ % stock would be required to purchase the railways alone, and considers that such an issue would create such a financial disturbance that it could not be seriously considered by those who really understand such matters. No doubt this is perfectly true, but we would point out that the resolution passed at the Hull Conference says nothing at all about *purchase*, and we do not think that *paying* for what is socialised in the "interests of the entire community" is part of the Socialist's creed.

*

Buenos Ayres and Rosario Goods Traffic.

THE annexed diagram shows the principal kinds of traffic and the seasons during which the same is carried by the Buenos Ayres and Rosario R. The relative sizes of the letters indicate the relative importance of the traffic at the particular



months under which they are printed. The diagram is reduced from a card issued by the Company and giving useful statistics and interesting items of information relating to their railway.

*

Working Agreement: Caledonian and N. British Rs.

IT was recently officially announced that the negotiations between the North British and Caledonian Cos. with reference to all classes of competitive traffic in Scotland has resulted in an agreement being completed under which, while the interests of the public are protected by the maintenance of efficient services on both systems, the companies will be enabled to effect considerable economies in working. The agreement, which also provides for the pooling of certain competitive traffic, both passenger and goods, and for the withdrawal of competitive trains, came into operation on the 1st of this month (February) and is to continue until 1936.

*

"Conciliation in Danger."

WE learn from *The Railway Review*, the official organ of the A.S.R.S., that conciliation is already in danger; indeed in the columns of this journal it has frequently been pointed out that the settlement refers only to hours and wages and that railway men are free to strike about any other grievance whenever they feel so disposed. The particular danger referred to arises out of the desire of the management of the L. and North Western R. to ascertain whether their staff wish the Co. to pay *all* the expenses of the new Conciliation Boards. This seemed to be a reasonable proposal and a generous offer, and the only way to find out was by a ballot, which, however, acted like the proverbial red rag on Mr. Bell, and he indited a somewhat furious letter on the subject to the Board of Trade. He received a cool and courteous reply which informed him that the knowledge must be obtained, that the Board proposed to ask the question on their Ballot Papers, but that "it must be clearly understood" that the Board threw "no reflection whatever upon the action "of the Company, who are now taking a vote of their staff "upon the subject, and, in fact, consider that an answer to the "question is one which is quite within the province of any "company to request." Now that the Labour Party has definitely declared itself to be the Socialist Party, we are afraid "Conciliation" has stormy times in front of it, and Mr. Bell's position will become precarious, as it is well known that he is not a Socialist.

Brake Van with Ballast Spreading Plough; Caledonian Railway.

By the courtesy of Mr. J. F. McIntosh, M.Inst.C.E., locomotive, carriage and wagon superintendent of the Caledonian R., we are able to publish the drawings of the Brake Van with a Ballast Spreading Plough, and of which we gave a photographic view and description in our issue for May, 1907.

The length over the headstocks is 21ft. and over the buffers 24ft. 4in. The width over the body 7ft. 5½in. and over the plough 8ft. 3in. The wheel-base is 9ft. and the wheels 3ft. 2in. diam.

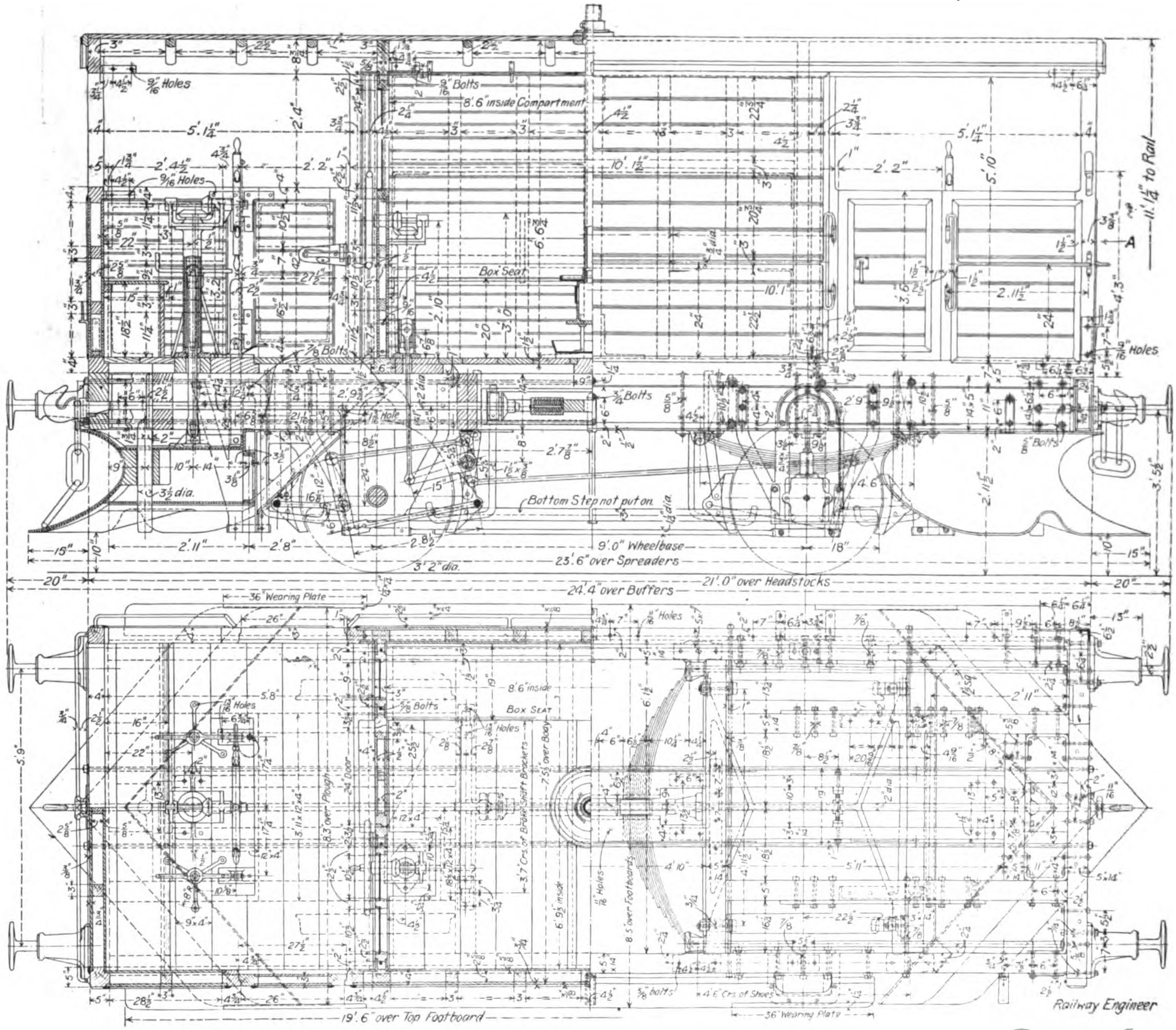
The under framing is built of timber, the sole-bars, headstock and other principal members being 14in. by 5in., joined together with strong bent plate knees and through bolts. The middle longitudinals are 3in. by 14in. and there are four longitudinal tie rods from headstock to headstock each 1in. diam.

The buffer springs and draw gear are carried back under the middle of the van clear of the ploughs and their attachments.

Each end of the van is fitted with a spreading plough and the necessary lifting mechanism, which consists of a screw worked by bevel wheels and hand wheels. Long links connect the nut on the screw to the plough, which at its front end is guided by a vertical bar 3½in. diam. fixed by a flange (bored to allow the draw-bar to pass through it) to a cross member of the under frame and which passes through a casting fixed in the angle of the plough as shown. The wings of the plough are connected and stiffened by a channel bar and angle, and these bars pass through two vertical guides bolted to longitudinal members of the under framing. These guides are stiffly stayed with angle-steel brackets and take the thrust of the plough when it is spreading the ballast.

There are two auxiliary lifting screws, one on either side of the main lifting gear. These are to take the weight off the main gear, and to draw the plough up close under the under frame when the plough is not at work.

The whole length of the van is roofed. The compartment for the men is 8ft. 6in. by 6ft. 9½in. inside. It is provided with box seats along both sides and with a stove, the chimney of which is held tight as it passes through the roof by set screws, which also secure an air space round it. The outside of the van is fully provided with foot-steps and hand-rails.



Screws are provided between the underside of the sole-bar and the top of the spring-buckle to prevent the end of the van dipping when the plough is in operation.

The journals are 8 by 4½, and have oil lubrication.

The weight of the van complete is 12 tons 3½ cwt.

Books, Papers and Pamphlets.

Moving Loads on Railway Underbridges. By HARRY BAMFORD. Whittaker and Co., London and New York.

This book consists of seven chapters, four of which are reprinted with the illustrations from *Engineering*, the other three being written as an introduction to the remaining chapters.

The three introductory chapters are not easy reading, and the wording could have been improved in several cases; for instance there is some confusion in the meaning of positive and negative bending moments, and the statement that ordinary beams "bend concavely upwards" seems doubtful. In the ordinary acceptance of words both beams and cantilevers bend downwards, whilst the concavity is at the upper surface in the beam and at the lower surface in the cantilever.

We disagree with the statement that where a beam extends over a support some distance that "the resultants of the load will pass through the centres" of the length overhanging the bearings. This will be the case in a beam of infinite stiffness, but if a beam deflect at all under load the pressure on the abutments must become greater at the face of the abutment than at the back.

We learn for the first time that the values of bending moments under railway loads are "usually increased by 2½ per cent. to provide for possible future increase of the axle loads of the type trains." It appears to be a very cursory way of disposing of the very debateable point, viz., as to what percentage should be allowed for impact, varying loads, stresses of alternate senses, proportion of dead to moving loading, etc., and which from time to time has given rise to much discussion amongst engineers responsible for bridge-construction.

The method adopted by the author for ascertaining the bending moments and shears for a system of train loads travelling over a bridge is a very old and simple one, and was used by the reviewer many years ago.

The funicular polygon is used, and the position of the load which will give the maximum bending moment is only that found by the ordinary text book formula "the maximum bending moment under any load occurs when that load and the centre of gravity of the whole series on the span are equidistant from the centre of the span."

The shear also is found by the ordinary graphic method of the closing line of a funicular polygon and a new vector drawn parallel to this from the pole of the force diagram. The method adopted by the author is little better than the old method of trial and error, and may take up quite as long a time to work out.

The notation of the diagrams might have been much improved if Bow's system of placing letters or figures between the loads had been adopted, and the diagrams would have been clearer.

Taken as a whole the book will be of great service to all those who have to design girderwork, and the introductory chapters especially form a short and fairly clear exposition of how to ascertain the stresses both as regards the bending and the shear of many types of girders and cantilevers.

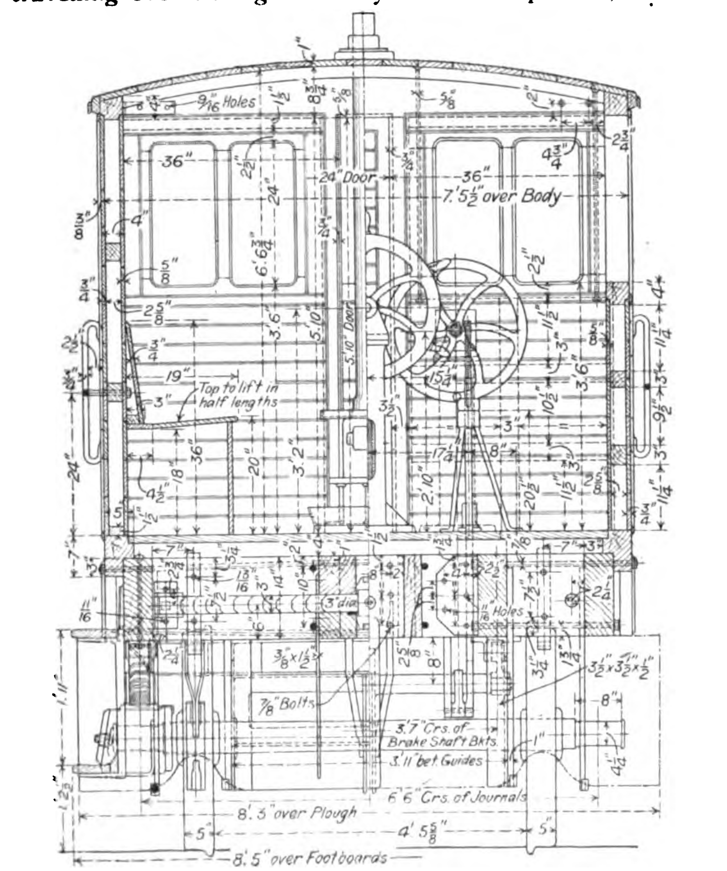
The description of the ascertaining of moving loads equivalent to those actually existing where travelling weights pass over bridges is well set down, and may save the engineer a vast amount of trouble that he would otherwise experience if a method of finding such equivalent loading had to be worked out "de novo."

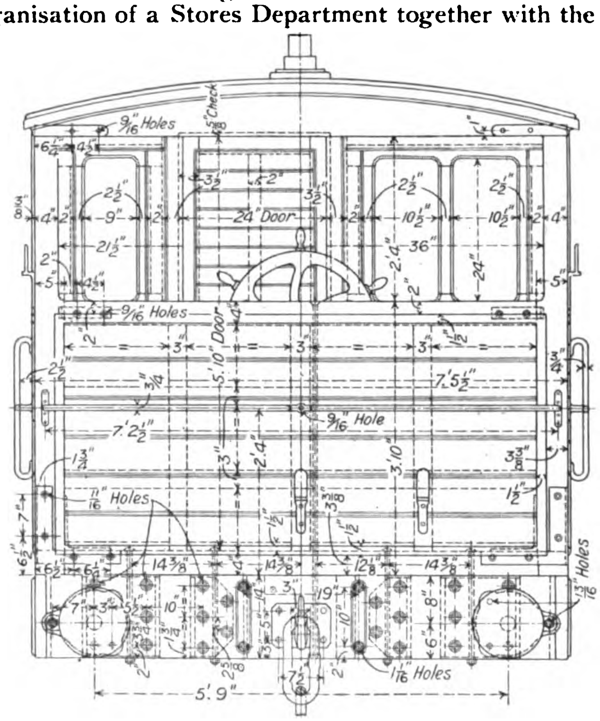
Why the title "Railway Underbridges" should have been used is not apparent, since the same methods of calculation, and in fact the consideration throughout, would apply to all bridges and girders where provision has to be made for concentrated moving loading.

*

The Principles of Railway Stores Management. By WILLIAM OKE KEMPTHORNE. London: E. and F. N. Spon, Ltd., 57, Haymarket. New York: Spon and Chamberlain, 123, Liberty Street.

Whilst this book is based on the experience gained by Mr. Kempthorne on Colonial railways yet the views he expresses are applicable to the management of the Stores Department of any English, Foreign or Colonial railway. It is divided into six parts:—Part I., general; part II., the staff; part III., the purchase department; part IV., the storekeeping department; part V., the accounting department; part VI., the inspection department. These are sub-divided into 26 chapters and there are two appendices, a list of forms and books, and concludes with a good index. The work deals with the organisation of a Stores Department together with the duties





View looking at end marked "A."

Brake Van with Ballast Spreading Plough; Caledonian Railway.

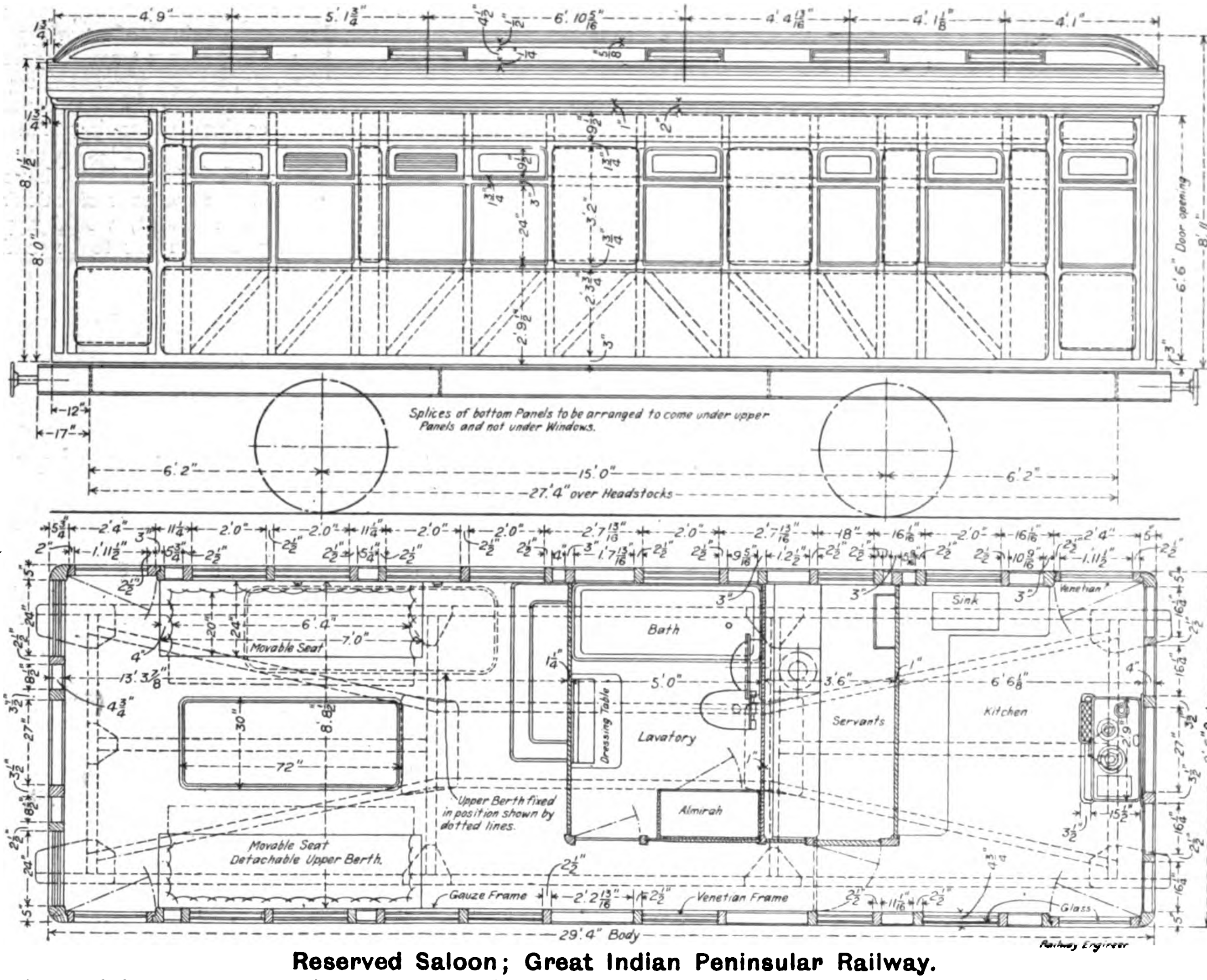
of the staff and their division and relations to each other, also with the lay-out of the necessary buildings, the books and forms required. Central and divisional stores are considered and the necessities of the various departments. The purchase of goods in England by indent is dealt with very fully and this part of the work should be exceedingly useful to officers in similar positions. That, however, is only one of many directions in which guidance and assistance may be obtained. The whole subject is dealt with very thoroughly—in fact it is done almost too thoroughly, as Mr. Kempthorne considers each point, submits the *pros* and *cons* when there are two sides of the question, advances arguments, then sums up the matter and gives the conclusion.

*

BULLETIN No. 4, *Tests of Reinforced Concrete Beams*, has recently been issued by the University of Illinois Engineering Experiment Station. The tests described are a continuation of the tests discussed in Bulletin No. 4. The topics investigated include the effect of quality of concrete upon the strength of beams, the effect of repetitive loading upon the action of beams, and the resistance of beams to diagonal tension failures. The results of the investigation of diagonal tension failures throw light upon the amount of the vertical shearing stress which may be allowed in reinforced concrete beams not having metallic web reinforcement. The resistance of beams to diagonal tension may be the controlling feature of relatively short beams, and as such failures occur suddenly and without much warning a knowledge of the resistance of the concrete is essential. Some beams gave surprisingly low values, and it seems evident that the values allowed by many city building ordinances are higher than should be recommended. The tests of concrete columns and reinforced concrete columns and of reinforced concrete T-beams for 1906 have already been published.

RECEIVED.

Moving Loads on Railway Underbridges: including Diagrams of Bending Moments and Shearing Forces and Tables of equivalent uniform Live Loads. By HARRY BAMFORD, M.Sc., Assoc.M.Inst.C.E. Whittaker and Co., 2, White Hart Street, Paternoster Square, London, E.C., and 64-66, Fifth Avenue, New York. 1907. [78 pp.; 8½ by 6¾; price 4s. 6d. net.]



Reserved Saloon; Great Indian Peninsular Railway.

IN our issue of August, 1906, we illustrated a special saloon designed by Mr. Bell, carriage and wagon superintendent of the Great Indian Peninsula R., and we are now able by that gentleman's courtesy to publish the annexed general drawing of the vehicle.

These saloons were built for the use of private shooting or touring parties who wish to stay at wayside stations.

The body is 29ft. 4in. long by 9ft. 6in. wide over corner pillars and is divided into three compartments. The saloon contains two couches or movable seats so arranged that they can be used as sleeping berths, and further sleeping accommodation is provided by means of detachable upper berths.

The lavatory compartment is 5ft. long and is fitted with a bath, folding lavatory, and w.c.

The kitchen is the full width of the carriage and is fitted with a stove and other necessary cooking appliances. Between the kitchen and lavatory is a servants' compartment.

At the saloon end there is a door so that, if required, two carriages can be connected by a vestibule gangway.

The body is carried on a steel under frame 27ft. 4in. over headstocks; there is thus 12in. overhang at each end; there is also considerable overhang at each side; this of course keeps down the weight of the under frame.

The wheel-base is 15ft.

Roofs.—VI*.

In this article several cases of roof trusses will be given which in some particulars are unique in their design and in the treatment necessary for the determination of the stresses in the bars.

The first case is that of a cantilever roof placed against a wall or other abutment on the one side and overhanging, say, a railway platform too narrow to allow of a row of columns being placed to carry the roof. The simple form of cantilever roof shown in fig. 37 does not present any diffi-

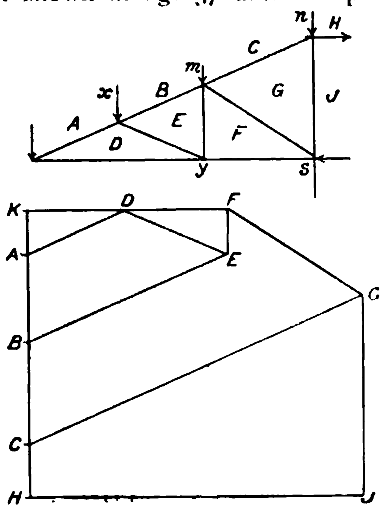


Fig. 37.

culty; it is only necessary to set down for the stress diagram the loads KA, AB, BC and CH, and to commence the diagram from the extreme end of the cantilever frame. Here then, for a commencement, the load KA is resolved into its components KD and AD, parallel to the respective bars in the outline diagram above.

For the next joint at x we have already found the stress AD, and the load AB being also known, these in combination give the resultant, which may be imagined as BD, although it is not actually drawn in the diagram. This imaginary resultant BD is now resolved into the two directions DE and BE, and the bars meeting at the joint x are thus determined.

The next joint y is now to be dealt with, and for this we have given the stresses DE and DK, with an imaginary resultant KE, and this is resolved into KF and EF to complete the joint.

Now consider the joint m where there are already found the load BC and the stresses BE and EF. The resultant of these three forces may be supposed to be drawn from C to F, and this is at once resolved parallel to the bars above into the bars FG and CG. The load CH does not affect the truss, as it is carried directly upon the rear part of the truss or upon the abutment wall.

There will be a tension outwards at the top of the principal drawing against the wall, and a compression inwards at the foot. Taking the top joint m we have the stress CG and the load CH with the resultant HG, and this may be resolved into the horizontal pull HJ and vertical stress GJ again for the bottom joint s we have the stresses FG and KF and the upward reaction KH, and this again gives the imaginary resultant GH, which may be once more resolved into the two directions GJ and JH to complete the diagram.

When however the above cantilever principal is provided with a bracket, from the underside of the tie bar down towards the wall or column, as shown in fig. 38, several of the stresses are very materially altered, and the computation of stresses is made more complex in that the bars FG and FJ become indeterminate.

After making the outline diagram of the roof principal the loads are set down in the stress diagram as KA, AB, BC, and CH, and commencing at the front of the truss, we have the load KA resolved into KD and AD, and then with the load AB, and stress AD, with imaginary resultant BD there is no difficulty in finding DE and BE. With BE found and BC known the resultant CE is obtained, but as this has to be resolved into three directions the problem is indeterminate at this juncture.

Try now the lower joint y at the foot of the vertical EF; the stresses DK and DE give the resultant KE, but as this has to be resolved into three directions the problem again cannot be solved.

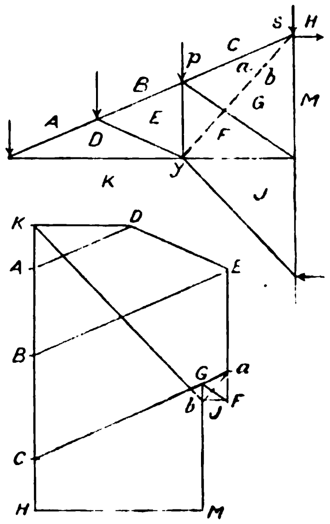


Fig. 38.

If, however, the bars FG and FJ are supposed to be omitted and replaced by the bar shown by a dotted line, the resultant CE of the load BC and stress BE can be determined into Ea and Ca, and for the lower joint y the stresses KD, DE and Ea being known, the resultant being Ka, this is without difficulty resolved into ab and bk parallel to the respective bars above.

Turning now to the lower joint y and removing the substituted member ab, and replacing the bars FG and FJ, and assuming no alteration in the bar bK, or what is identical, JK, we find that we have the incomplete stress diagram bK, ND, DE, with resultant Eb, to which there is no other method of completing the diagram in the directions EF and JF than by dropping a perpendicular from E and drawing a horizontal from J until they meet in F, and in fact we have replaced the dotted line ab by the full lines EF and FJ, or in other words, resolved the resultant aJ into the two directions aF and JF.

With EF thus found, we have now the load BC and the stresses BE and EF at the top joint p, with resultant FC, which is now resolved into FG and CG.

Now consider the top joint s; we have the stress CG and the load CH, with resultant HG, and this is resolved into GM and HM and the diagram of stresses is complete.

In fig. 39 is shown another variant of the same cantilever roof truss with another difference, and that is the alteration

*The previous articles of this series appeared in the *Railway Engineer* as follows:—I., May, 1907; II., July, 1907; III., September, 1907; IV., October, 1907; V., December, 1907.

of the design of the bracket under the lower part of the truss against the wall, and a complexity which leads to the employment of two temporary or substituted bars ab and ac instead of only one substituted bar as in the last case.

After drawing the outline diagram of the truss and the line of loads as before, we easily find the stresses ND, AD,

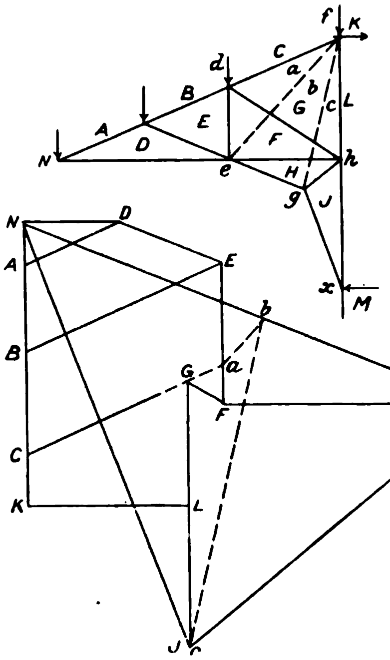


Fig. 39.

DE, BE, but as the stress EF is unknown there is the same difficulty at both the top and bottom of the first vertical as previously, that two known forces cannot be transformed into three other forces, although the directions are given. At this stage then it is necessary to temporarily remove the bars FG, FH and HJ, and to substitute for these the dotted line bars ab and bc.

This done for the joint d we have the stress BE and the load BC known, with the resultant CE, which is transferred into Ca and Ea, whilst for the lower joint e we have the known stresses ND, DE, Ea, with resultant Na, to resolve into the directions ab and bN.

The next step is to translate the stress in the bar Nb at the joint g into the two components bc and Nc, and when this is accomplished we have for the top wall joint f, the known load CK, and the stresses Ca, ab, bc, with resultant Kc, to transform into the two directions KL and cL, which gives the point L.

At this juncture we remove the temporary bars and replace the original members, and at the same time replace the small letter c by the capital letter J in the stress diagram.

For convenience take the stress in NJ at the joint g as unaltered by the replacement of the bars and resolve this into NH and JH. Next consider the joint e, where we have the stresses ND, DE, NH forming a resultant HE, which may at once be resolved into the directions EF and FH.

For the joint d the load BC and the stresses BE and EF already known, the resultant FC is resolved into the directions FG and CG.

As a continuation of the argument, although the diagram is by this time perfectly complete, we can take the condition of the joint f, and having the load CK and the stress CG known, the resultant KG is found and resolved into GL and KL, whilst for the joint L we have given the stresses GF, FH, HJ, JL and GL, which all are shown to balance in equilibrium since they are all parallel to their respective bars in the truss diagram above.

It is desirable to check at least one of the values thus graphically found, say the pull from the wall at the top of the

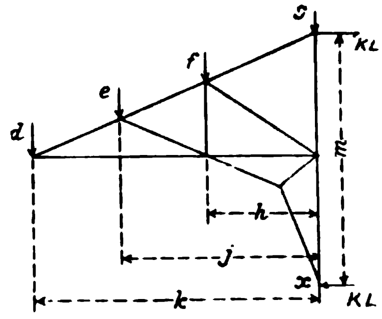


Fig. 40.

truss, and the thrust towards it at the bottom (see fig. 40). This can be done by the method of moments taken around the point x, and in this case we shall have for the pull at the top

$$(f \times h + e \times j + d \times k) \div m = KL,$$

which will be accompanied by an equal thrust at the foot of the truss.

The next description of a roof is shown by fig. 41, and is that of a roof overhanging on each side a pair of columns, a condition sometimes found over a railway station platform, where it is necessary to protect with a roof the full width of the platform, but where the columns must be kept some distance away from the platform edge.

The outline diagram of the truss is given at the top of the figure, and over each purlin is shown graphically the load that it is assumed to carry, the loading being intended to

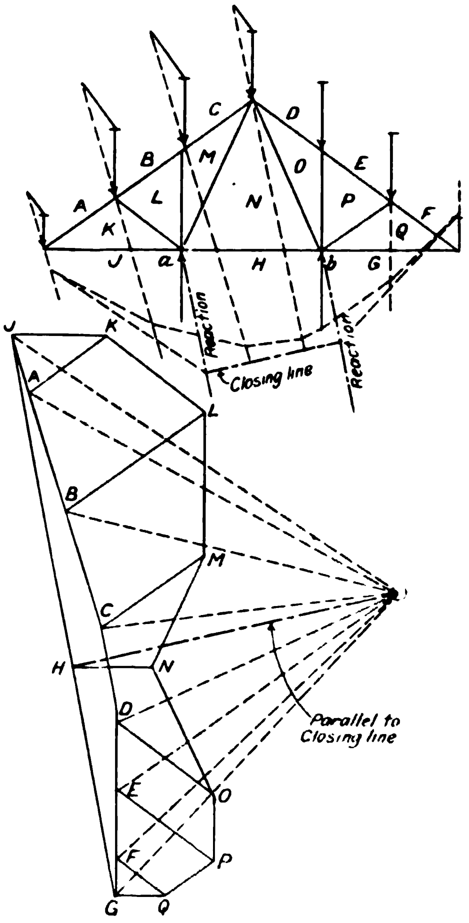


Fig. 41.

provide for wind on one side only, together with the dead load uniformly allowed at so much the square foot, the vertical and inclined loading being shown by lines drawn to the scale of the stress diagram, the two combined on the left-hand side for total loading.

When preparing the accompanying stress diagram, the first thing is to lay down the loads JA, etc., to FG in succession, and to connect the two extreme ends by a straight line JG which gives the resultant of the whole system of loading. To discover the values of the reactions of the two points of support a funicular polygon must now be drawn, and a closing line found as indicated on the outline diagram of the truss. From the pole of the vector polygon a line is drawn parallel to the closing line above to the point H which divides the two reactions JH and HG.

Now, commencing at the left hand, the load JA is resolved into JK and AK, and with AK and AB, resultant KB, the stresses KL and BL are found. Again, with stress BL and load BC, the resultant LC is found and resolved into LM and CM. Proceeding to the right-hand side, the load FG is transferred into GQ and FQ, and with stress FQ and load EF, resultant EQ, the stresses QP and EP are obtained. Again, with EP and DE known, the resultant DP is found, and this is resolved into the two directions PO and DO.

For the central or apex joint we have the stresses CM and DO, and the load CD, and it is obvious that the closing line or resultant of these is MO, which now has to be resolved into the two directions MN and ON to make the stress diagram so far complete.

To obtain the stress on the bar NH, if we take the joint a it is at once seen that the stresses JK, KL, LM, MN, have been already found, together with the reaction JH, and it only requires the line NH to complete the figure. Or, working around the joint b we have already GQ, QP, PO, ON, and the reaction GH, and the closing line again is NH, proving the accuracy of the computation.

The roof truss indicated in fig. 42 is another case that presents some difficulty in the working out of the stress diagram, particularly at the joint f, where two forces that may be determined have to be resolved into three directions, a condition at first sight impossible to determine.

After making the outline diagram, and setting down the line of loads, it is easy to find the stresses AH and GH, since it is obvious under this distribution of the loading that the line from A to G will be the value of each reaction.

In the enlarged diagram 1 we have the next step shown, which is to find the stress in the bars JK and LM from the normal component r of the load BC, when the component o in the direction of the back of the principal is assumed to travel downwards towards the reaction.

The enlarged figure 2 gives the stresses from this normal component r in the bars y and p, and if in the enlarged figure 3 the stress already obtained in the bar y be set down together with the normal component s of the load AB a resultant is found which may be transformed into two directions to find the value of the stress in HJ. If now the stress in HJ be set down as in the diagram 4, and resolved in the two directions, we have the stresses a and x found, due to HJ, but not necessarily of the correct values of the actual bars in the truss itself. That the stresses so found of the bars HJ and JM (a equals JM) are the correct stresses in the truss is seen when it is pointed out that it is only due to the loads AB and BC that there are any stresses at all in these respective bars, and that if the two loads named were removed then the stresses to meet the reaction AG would continue up to the ridge on the top and the foot of the king rod below without alteration, the intermediate bars being without stress at all.

Returning now to the proper stress diagram, and commencing at the point H, which has been already found, draw HJ produced from H of the length found in diagrams 3 and 4,

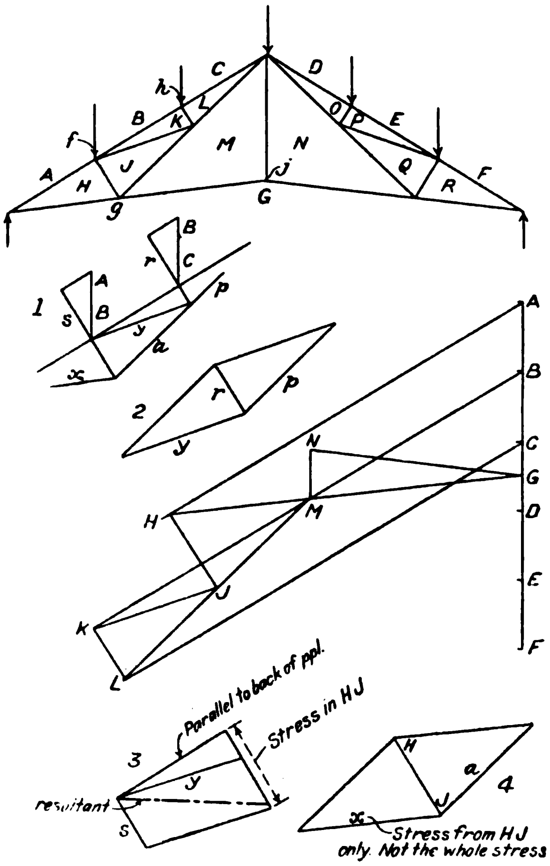


Fig. 42.

also KJ equal to y, and at this stage of procedure we have for the joint f the stress AH and the load AB, already known, with resultant BH, and if a line is drawn from B parallel to the bar BK in the truss until it meets K, just found, then it is discovered that the stresses BK, KJ, and JH will be equal to the resultant BH already found, and the stresses at joint f are completed.

For the next joint g the stresses GH and HJ are known, with resultant GJ, and it is only necessary to resolve this into JM and MG; whilst for the joint h, the load BC and the stress BK being known, the reaction CK is found, which without difficulty is resolved into KL and CL in the stress diagram.

For the joint j at the foot of the central rod, it is seen by symmetry that the stress in GN will be equal to GM, which is already found, and drawing GN parallel to the bar above in the outline of the truss, the value of MN is at once found, since the three reciprocal lines in the stress diagram must then be equal to the stresses in the joint j. To complete the figure for the apex or ridge joint it will be necessary to assume that one half of the apex load CD or CG travels downwards on this side of the roof, and with CL known the stress LM is found, and the diagram of stress for one side of the roof truss is complete.

Figure 43 is a stress and reciprocal diagram of the whole of the bars in the principal when the wind is blowing on the

left side of the roof. The vertical dead loads are shown as acting on the wall plate, each purlin, and the ridge, whilst the normal wind loads are indicated at each of the same points on the left side, and the combination of these are set down in their proper sequence in the reciprocal diagram below.

Now that the principle of the construction of the diagram

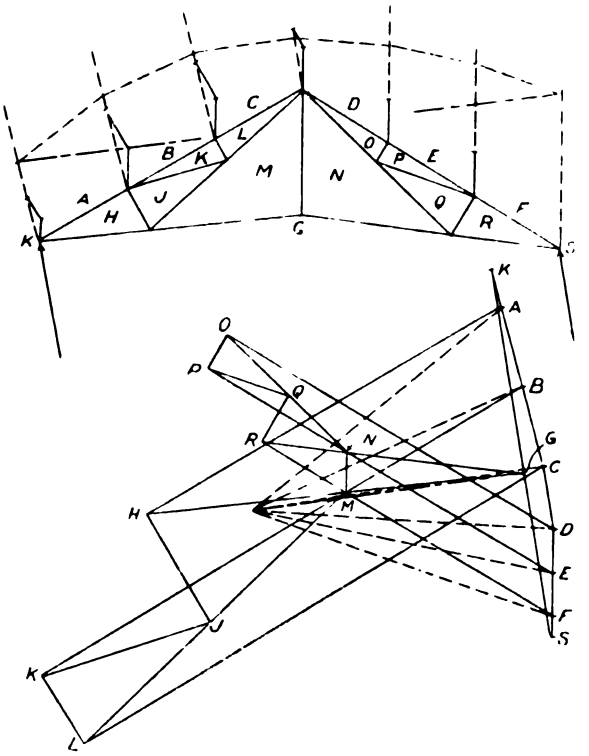


Fig. 43.

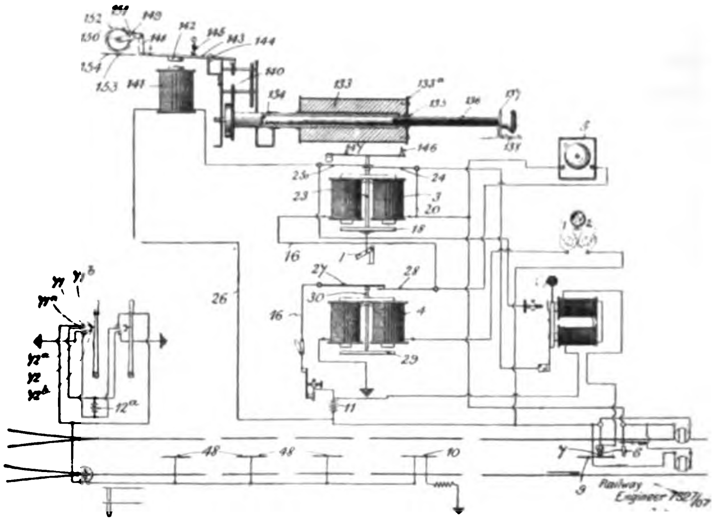
has been determined for the preliminary case of the uniformly distributed loading, the making of a corresponding diagram for irregular loading easily follows, and no further description is necessary. It will be noted that the assumption is made that both the points of support are fixed in such a manner that they can both be assumed to carry inclined loads as well as vertical.

(To be continued.)

Recent Patents relating to Railways.

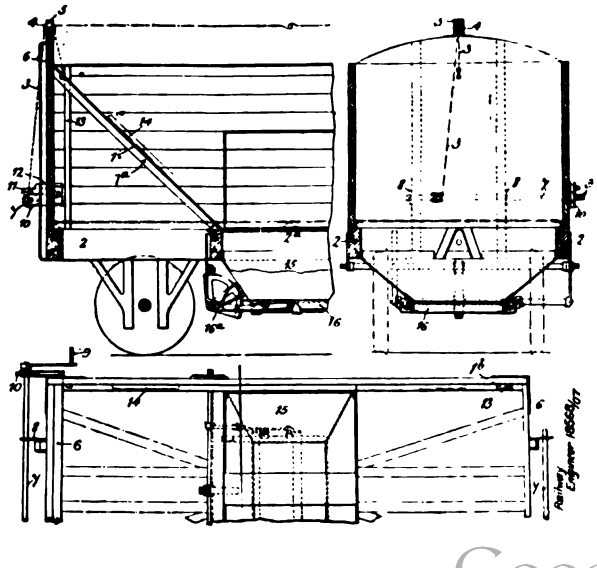
These abridgements of recently published specifications are specially compiled for this Review by Messrs Wheatley and Mackenzie, Chartered Patent Agents, 40, Chancery Lane, W.C., from whom copies of the specifications can be obtained at an uniform price of 8*d*. each.

Signalling Apparatus. 7,527. *28th March, 1907. V. L. Raven, Alpine Cottage, Darlington, Durham.*
This invention is applicable to signalling apparatus wherein visual and audible signals upon an engine are operated to give a warning signal when the engine approaches near to a line signal or signalling point by the action or influence of a track device over or past which the engine then travels, whether the line signal be at "danger" or not, and is caused to indicate "danger" by the continuance of the warning signal, or "line clear" respectively, in accordance with the position of the line signal, by the action or influence of another track device that is under the control of a signalman and is operative for the purpose of indicating "danger" or "line clear" only when the means for actuating the line signals are in the positions corresponding thereto. According to the present invention there is provided on the engine in conjunction with the signalling apparatus signal recording apparatus so arranged as to come into action when the signalling apparatus is brought into operation and make a record of such operation, and to be put out of action when the signalling apparatus is put out of operation. The recording apparatus may comprise a record sheet or tape, means for moving the same forward, and a recording device, such as a pen, pencil, or equivalent arranged to cause an indication to be made on the record sheet or tape only when and whilst the signalling apparatus is in operation. The record sheet may be mounted on a carrier 133 arranged to be driven automatically by suitable means, such as clockwork 140, and to be started and stopped by a device under the control of an electro-magnet 141 that is itself controlled by current passing through the circuit including the electro-magnetic mechanism used for bringing the visual and audible signalling devices into operation, whilst the recording device 146 may be brought into action by the movement of same mechanism, the arrangement being such that when the visual and audible signalling devices



are brought into operation to notify the fact that the engine, fitted with the apparatus, is near to a distant signalling point, the record carrier will be set in motion and the recording device will be brought into the operative position and produce a record, and when the signalling devices are put out of operation the recording device will be moved into the inoperative position and the record carrier stopped. (*Accepted 24th October, 1907.*)

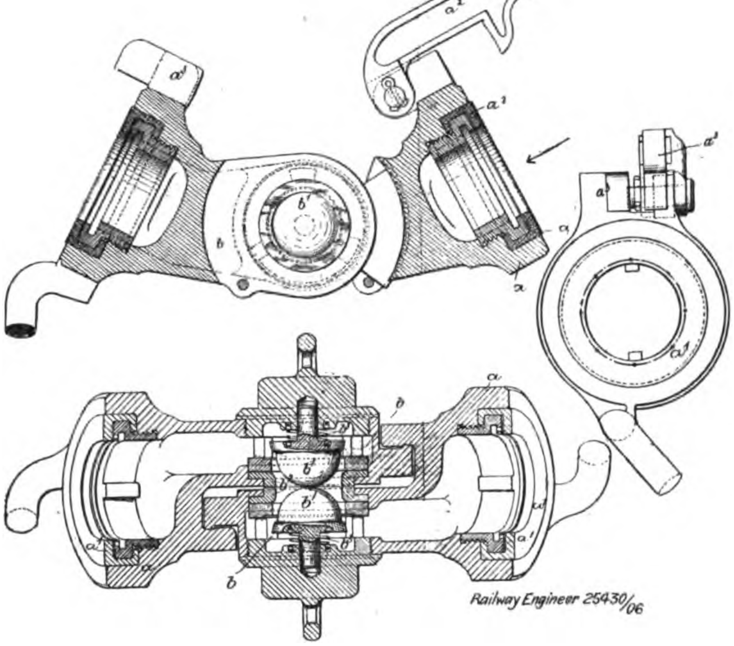
Wagons. *18,568. 16th August, 1907. G. B. Bowles, 37, Avenue Road, Forest Gate, London.*
This invention relates to wagons that are convertible at will from flat bottom to self-discharging hopper wagons. The floor is formed of two flat metal plates 1, strengthened by angle irons, and adapted to rest horizontally on the underframe 2 closing the discharge opening 2*, or to be raised into



the inclined positions shown by chains 3 passing over pulleys 4 to a winding shaft. Extending across and suitably suspended from the lower side of the wagon underframe 2 and below the discharge opening 2^a is a discharge hopper 15 arranged centrally with respect to the abutting ends of the plates 1. The opening at the bottom of this hopper is normally closed by a sliding and tilting door 16, that is adapted to be partly opened in a longitudinal direction by hand-operated mechanism 16^a and to be afterwards caused to automatically tilt into its fully open position by the weight thereon of the contents of the hopper to allow of the discharge of such contents, after which it will automatically assume its horizontal position and can be closed by hand. (*Accepted 17th October, 1907.*)

Couplings for Steam Train-Pipes. 25,430. *12th November, 1906. F. W. Marillier, "Deva," Westlecott Road; S. and G. H. Pearson, The Veronfieff, Westlecott Road, Swindon, Wilts.*

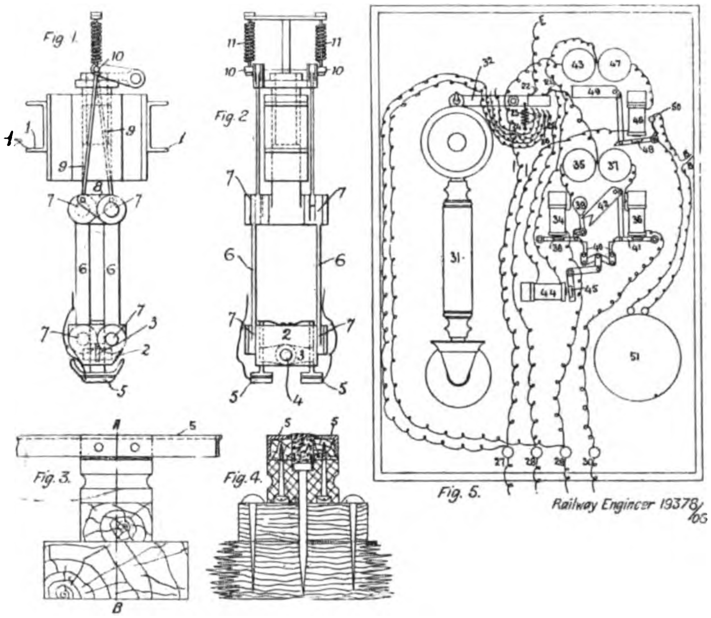
According to this invention a pipe connection is provided for conveying steam for heating trains, which is applicable to carriages which are to be slipped with a view to retaining the heat in the slip carriage and in the carriages of the train



when slipped without adding to the duties of the slip carriage attendant. The connection comprises an adapted coupling constituted by two halves each consisting of a half coupling *a* of the standard heating type and a half coupling *b* of the "Westinghouse" type provided with a valve b^1 adapted to be opened on coupling and to close automatically on parting. (*Accepted 10th October, 1907.*)

Signalling Apparatus. 19,378. *30th August, 1906. A. C. Bouneviallc, 181, Queen Victoria Street, London.*

This invention is an improvement on a prior patent, No. $13{,}932^{02}$, for electrical signalling apparatus arranged to indicate to the driver of a locomotive the position of the ordinary signals, and to put him in electrical communication with the signalman. For this purpose a third rail having two conducting surfaces insulated from each other is placed in electrical communication with the signal-box and with the cab of the locomotive by a collecting brush carried on the locomotive. The shoe 2 of the brush is constructed with a transverse rocking lever 3 pivotted at its centre 4 and carrying at each end one of the contact pieces 5 which are insulated from each other and from the shoe 2. Each shoe is carried by two vertical arms 6 pivotted at each end 7 so as to ensure parallel movement thereof and maintain the contact pieces 5 in a horizontal position. The vertical arms 6 have each a projecting arm 8 to which are connected flexible rods, or cables, 9, attached to the spindle 10, supported by the springs 11 which serve to bring the brush back to its normal, or vertical, position. When the collecting brush enters upon a section of the line provided with a central rail, should the engine be passing over the "distant" signal section and the signal be at "danger" the circuit is formed through the coil 34, and thence through the red lamp 35, the contacts 21 and 22, and the metal work of the engine and track rails, to earth. Should the "distant" signal be at "line clear" the circuit will be formed through the coil 36, and the green lamp 37, and thence through the contacts 21 and 22, to earth. The current in passing through the coil of the electromagnet 34 attracts

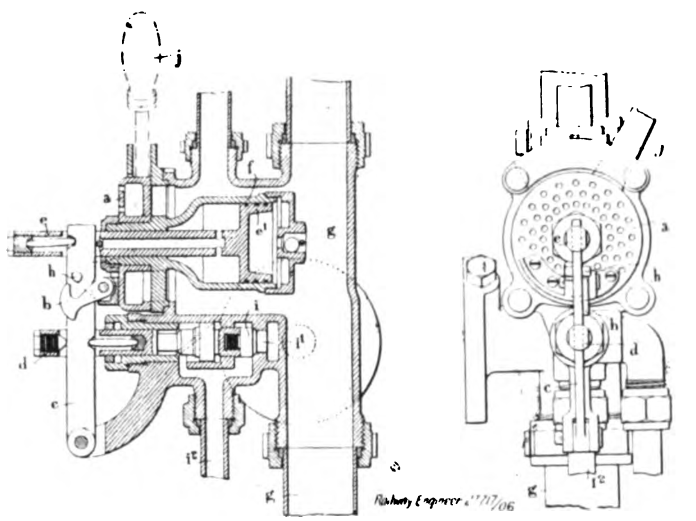


the armature 38 and moves the flag indicator 39 from behind a cover, or shutter, exposing it to view, indicating thereby that the "distant" signal was at "danger" when passed, the flag being retained in this position by the catch 40. Fig. 5 shows the "distant" signal as having been taken off whilst the locomotive is passing over the section, the act of taking off the signal causing, at the same time, the circuit to be changed from the electromagnet 34 and lamp 35 to the electromagnet 36 and lamp 37, whereby the armature 41 has been attracted and has caused the semaphore. 42 to be lowered, where it is locked in position by the catch 40. On arriving at the "home" section should the signal be at "danger" the circuit is completed through the red lamp 43 to the electromagnet 44, which will cause the armature 45 to be attracted, releasing the catches 40, thereby allowing the "distant" signals to assume their normal positions, namely "danger." Should the "home" signal be at "line clear" the circuit will be completed through the electromagnet 46, the green lamp 47 and the release magnet 44, thereby causing the armature 48 to be attracted, lowering the semaphore 49, and by means of the release coil 44 releasing the catches 40. When the armature 48 is attracted by the electromagnet 46 it forms connection with the contact 50 and closes a local circuit to the bell 51, the leads B—B connecting it to the battery. When a telephone is provided on the indicating boards it is carried on a hook switch 32 which cuts the lamp and semaphore out of circuit by opening the contacts 21 and 22, and closes the telephone circuit by the contacts 23, 24, 25 and 26, when the telephone 31 is removed from the hook. (*Accepted 30th October, 1907.*)

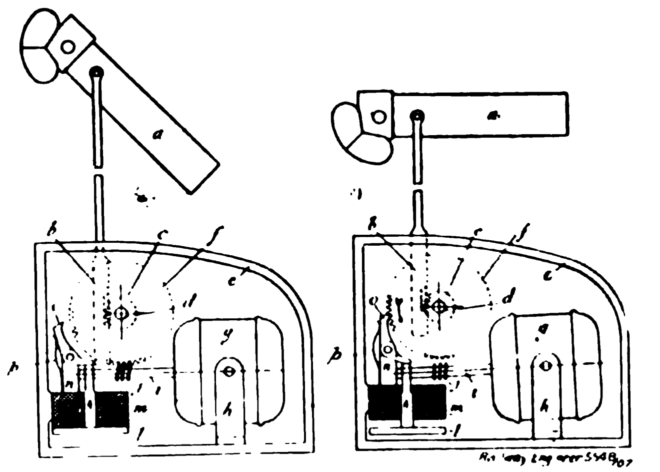
Steam and Vacuum Brake Valve Mechanism. *27,717. 5th December, 1906. H. E. Gresham, Craven Iron Works, Salford, Lancaster.*

In order to prevent when desired the operation of the steam valve when there is air in the train pipe a catch capable of automatic or positive release is arranged in conjunction with the hand-controlled lever of the air admission valve. The

catch *b* is mounted on the rotatable flat face *a* of the valve casing. Upon the pivoted arm or lever *c* which passes through the ends of the steam valve spindle *d* and of the rod *e* of the piston e^1 arranged in a cylinder *f* communicating with the train pipe *g* is fitted a pin *h* or its equivalent in such a position with respect to the catch *b* that when the latter is put into engagement with the pin the steam valve *i*, which has a piston like extension i^1, can pass no steam to the steam brake cylinders, but is allowed a slight movement with respect to its seat. The pin *h* and catch *b* will be held firmly in engagement, whilst air is in the train pipe, by reason of the steam acting through the steam valve spindle *d* on the lever *c*. When, however, a partial vacuum is produced in the train pipe *g* the piston e^1 will be moved so as to hold the pivoted arm or lever *c* and through it the steam valve *i* in their innermost and closed positions respectively, which permits the catch *b* to disengage itself by its own weight. Should, however, the catch *b* not disengage itself for any reason, it will be caused to do so when the hand control lever *j* is moved so as to admit air to the train pipe for the application of the brakes; for the rotatable face *a* of the air valve in its movement with the control lever *j* carries the catch *b* out of engagement with the pin *h*. The rise of pressure in the train pipe, by its balancing effect on the piston e^1, will now permit the steam to open the valve *i* and thence to pass by way of the pipe i^2 to the steam brake cylinder. When a partial vacuum is again produced in the train pipe the piston e^1 will move the arm *c* to close the steam valve *i* and the catch *b* can then, when desired, be placed by hand in its operative position. The closing of the steam valve automatically puts the pipe i^2 into communication with exhaust for releasing the steam brakes. (*Accepted 10th October, 1907.*)

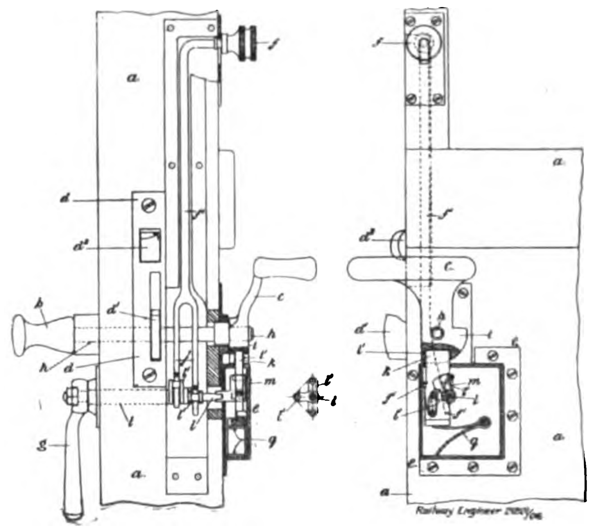


Electrical Signal Operating Apparatus. 5,548. *7th March, 1907. Siemens Bros. and Co., Ltd., 12, Queen Anne's Gate, Westminster, and L. M. G. Ferreira, 102, Elmbourne Road, Upper Tooting, Surrey.*
The semaphore arm *a* is connected with a rack *b* gearing with a pinion *c* fixed to the shaft *d*. The latter is carried in a bearing formed in the casing *e* and has keyed to its inner end a worm wheel *f*. An electric motor *g* is pivoted at or near its centre of gravity in a cradle *h* fixed to the casing *e*. The shaft *i* of this motor is carried at its free end in a bearing formed in a rod *k* near the end thereof, and has on it a worm *j* adapted to gear with the worm wheel *f*. In the construction shown the rod *k* constitutes part of the armature *l* of an electromagnet *m* fixed to the casing; it is obvious, however, that the connection between the rod and the armature may be any which will cause them to move together in the desired manner. To a support fixed to the casing, preferably to a bracket *n* on the magnet *m*, is pivoted a pawl *o*, the tail of which rests on or is linked to the end of the rod *k*, while the other end is adapted to engage the worm wheel *f* if necessary under pressure of spring *p*. The bracket *n* may also serve as a thrust block for the end of the shaft *i*. In the normal position, shown in fig. 2, the pawl *o* is in engagement with the worm wheel *f*, so that the signal arm is locked in the danger position. The magnet *m* being without current the armature *l* is not attracted, and either by its weight or under pressure of spring *p* keeps the motor *g* tilted on its pivots so that the worm *j* is out of gear with worm wheel *f*. When the signal is to be lowered a current, which may be a separate detection or control current, or a shunt from the motor circuit, is supplied to energise the magnet *m* and the motor is started, the necessary circuits being completed in any known manner. The armature *l* being thus attracted, the pawl *o* is



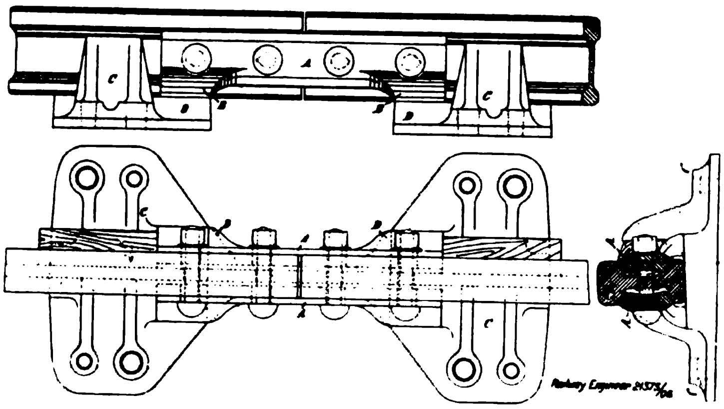
brought out of engagement with worm wheel *f* and worm *j* is brought into gear with the said wheel so that the latter is immediately revolved in the direction indicated by the arrow in fig. 2 and the signal arm is lowered, the position of the parts then being that shown in fig. 1. The motor is now automatically switched off, and as long as the magnet *m* remains energised the worm wheel *f* and therefore the signal arm remain locked by the stationary worm *j*. When the control current is cut off the armature leaves the magnet and brings the worm *j* out of gear, whereupon the signal arm immediately returns to danger under influence of its couterweight and pawl *o* locks it in that position. (*Accepted 24th October, 1907.*)

Fasteners for Carriage Doors. *21,801. 3rd October, 1906. W. L. Gorst, Wynfield, Lathom, Ormskirk, Lancaster.* According to this invention, the fastening comprises two parts, namely, the handle *c* and snack or catch d^1 operated by it, and a locking part *e*, operating in connection with same, and which is actuated by a separate device from within, and without. This locking device *e* is operated from within the carriage by a knob *f*, and outside the door by a handle *g*, which can be operated by porters or others on the platform,



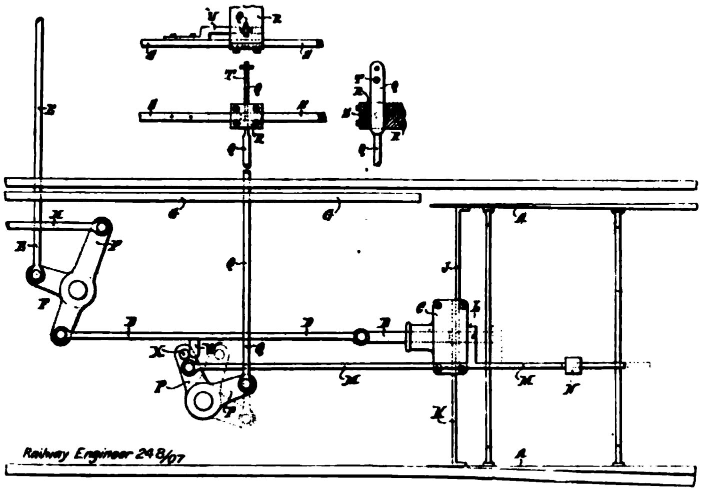
so that when the door is fastened by the ordinary fastening it can be unlocked and relieved by this handle, as well as by the device within the carriage. The two handles *c* and *b* are mounted upon the main spindle *h*, and in connection with same there is provided a partial disc or wheel *i* which, in the case shown, is on the underside of the handle *c* itself, and which is revolved by the handles when turned; and this partial disc *i* has in its periphery an aperture i^1, while below it the lock mechanism *e* is disposed, which comprises a locking bolt *k* which, when the main handles are actuated so as to fasten the door, is moved outwards automatically, and into engagement with the recess or aperture i^1, so locking the main fastening and handles of the door; whilst when moved in the other direction it withdraws this bolt *k* from the partial disc *i*, and so allows the main fastening d^1 to be worked. The movement of the locking bolt *k* into engagement with the partial disc *i* is only possible when the main fastener is closed. To open the door from within, two actions have to be performed when the main fastener d^1 is locked by the bolt *k*, namely, first of all the main fastener has to be unlocked by withdrawing the bolt *k* from the partial disc *i*, which can be done by pressing down the push device *f*, which, by the cranks *l*, l^1 turns the key *m*, thereby drawing down the bolt *k* out of the recess i^1. The main fastening handle *c* can then be turned in the usual way, and the door unfastened and opened. The bolt *k* is normally pressed up by the spring *q*. Hence the action of opening a carriage door which has been locked by the lock *e* is not effected by simply turning the single handle *c*, which exists on the inside; and so the likelihood of the door being opened by people playing with the handle or turning it inadvertently is very much reduced. *(Accepted 3rd October, 1907.)*

Rail Joints. *21,375. 27th September, 1906. W. Marriott, The Grange, Brinton, Melton Constable, Norfolk.* The fish plate is so constructed as to form a bridge or arch joint supported at each end by the chairs or sleepers and supports the extremities of each rail independently. At each end of the fish plate A there is a foot B which rests upon the



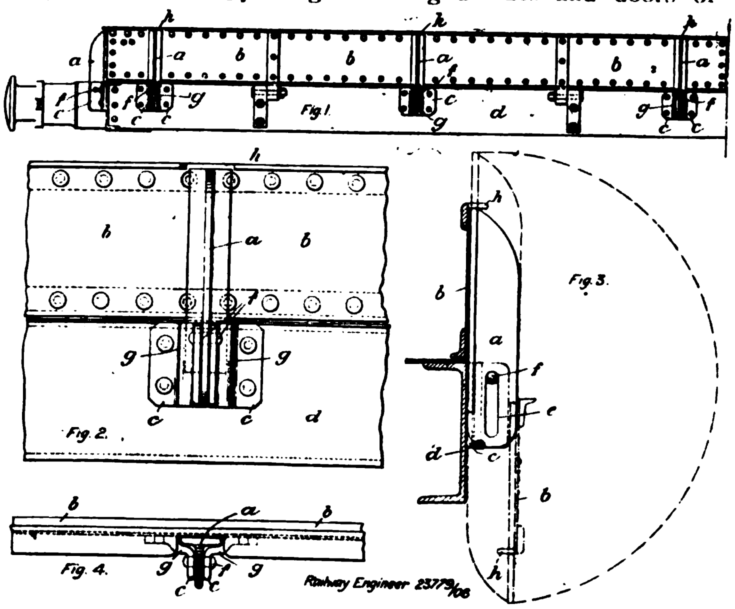
nearest chair C, which is provided with an extended portion D for the purpose, or the extended portion D may be a separate plate secured to the sleeper. If desired the foot B may be extended throughout the length of the fish plate so that it can be rolled instead of stamped in being manufactured. *(Acceped 27th September, 1907.)*

Interlocking Points and Signals. *248. 4th January, 1907. P. Smart, Hill Street, Ladybank, Fife, N.B.* In connection with the facing points A the usual locking bolt B is provided. When the bolt B is being shot it encounters and pushes before it a projection L on a rod M passing at one end through a supporting block N and connected at its other end to one arm of the bell-crank lever P centred in the four-foot way. To the other arm of the lever P there is connected one end of a second rod Q extending transversely to the side of the line where the various signal rods or wires are carried. The outer end of this rod Q is flattened and acts as a detector sliding in a groove formed for it in a supporting chair or block R, through which also passes a rod S for operating the home signal. When the projection L and the rod M has been moved endwise the bell-crank lever P is so moved that the detector slide Q is also pulled endwise. An aperture T in the end of the detector slide is then put in such a position that when the home signal lever is actuated a detector bolt U carried by the home signal rod S passes freely through the aperture T and the home signal is lowered. In the event, however, of the facing point locking bolt B or its connections being so damaged that the bolt has not been made to travel in order to lock the points, these are then unlocked though thrown. In this position of the parts it is impossible for the signalman to lower the home signal, as the detector



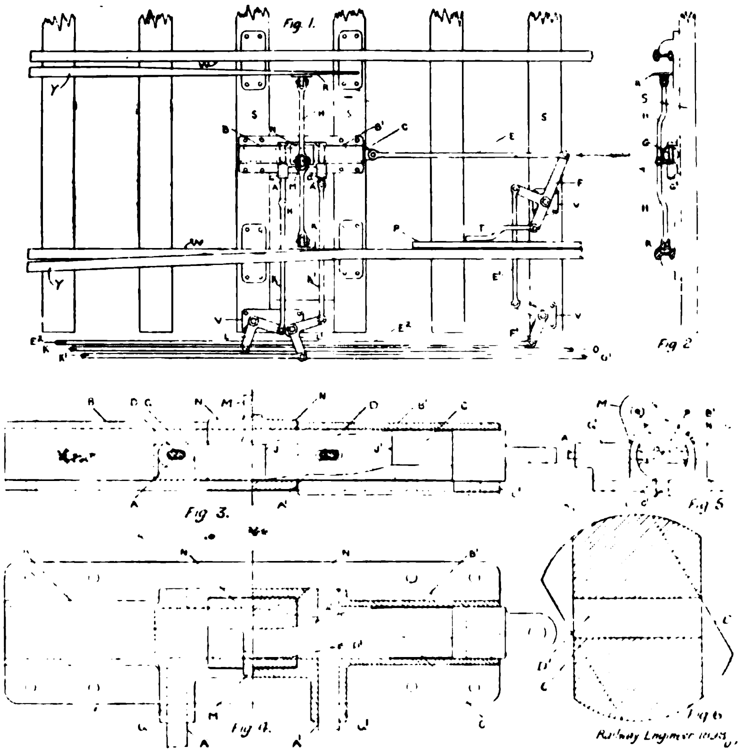
slide Q has not been moved and its unperforated portion prevents the end on movement of the detector bolt U and consequently of the rod S actuating the home signal. If, however, the parts have worked correctly and the home signal has been lowered, when it is raised again and the facing point locking bolt B is being withdrawn a projection W on the actuating rod D carrying the bolt so acts on a projection X on the bell-crank lever P as to return that lever and the parts connected therewith to the desired position in which the detector slide Q prevents the lowering of the home signal. *(Accepted 17th October, 1907.)*

Wagons. *23,779. 25th October, 1906. C. H. Fox, Alderman's House, Bishopsgate, London.* In order to prevent the breaking away of the stanchions and stops used for supporting the hinged sides and doors of



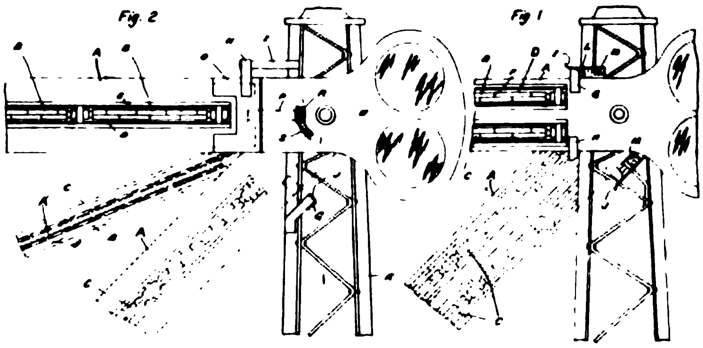
wagons, the stanchions *a* or stops are connected to the wagon underframes by pin and slot connections *e*, *f*, which allow them to be moved vertically out of their rockets *c* and turned out of the way. *(Acceped 26th September, 1907.)*

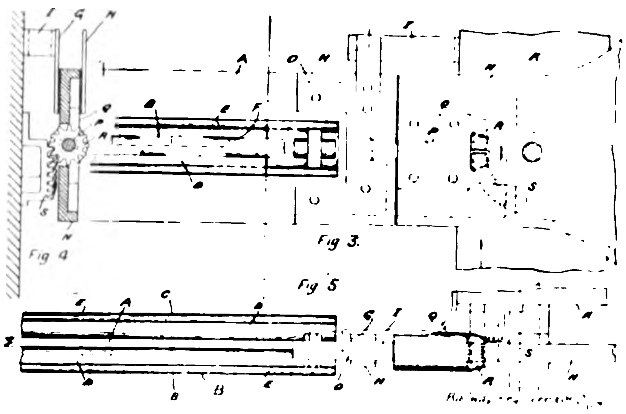
Points and Signals. *1898. 25th January, 1907. W. Taylor, of Taylor Bros., Midland Foundry, Sandiacre, Derby.* The detectors A A^1 of the signals are arranged to pass through guides G G^1 in bearings B B^1 and through a slot B^1 in a helical element or screw C mounted to slide in the bearing frame B B^1. A nut N is threaded on the screw C. The nut N is threaded and is rendered incapable of reciprocation, being supported in and between the bearing brackets B B^1 in such a manner that it is capable of being rotated about one-quarter of a revolution when the screw C is drawn or forced through it, this element being rendered incapable of rotation by the tongue piece C^1 sliding in a slot in bearing B^1. The nut N is formed with an arm M, which is attached by the connecting rods H H to the switch or point rails R R. The helical element C is actuated by connecting rods E E^1 and E^2 and bell-crank levers F F^1 from the signal-box or elsewhere; and the signal detectors A A^1 are each also actuated from the signal-box or elsewhere by the connecting rods K K^1 and bell-crank levers L L^1. The signals or semaphores are actuated by connecting rods O O^1 attached to the bell-crank levers L L^1, and the lifting bar P of the switch is actuated by rod T attached to one arm of the bell-crank lever



F. If a train be moving in the direction of the arrow towards the switch R R so as to run into the road W, this switch must be quite closed—as shown by fig. 1—before the "line-clear" signal at end of rod O^1 can be given, by reason of the fact that before this signal can be given the detector A^1 attached to same must pass through the slot D^1 in the helical element C which is locked thereby. And further, from this it will be seen that the switch R R cannot be moved from the position shown by fig. 1 until the detector A^1 is withdrawn from the slot D^1 in the helical element C, when the signal attached to rod O^1 will be caused to be set to "at danger." Further, when it is desired to pass a train moving in the direction of the arrow shown in fig. 1 into the other road Y the detector A^1 must be withdrawn from the slot in the helical element C, and both signals attached to rods O O^1 set to "at danger" before the helical element C can be moved in its bearings from right to left; so that the twisted portion of the element from J to J^1 (fig. 3) will slide in the nut N, and thus cause same to partially rotate and throw the switch over into the opposite position to that shown by fig. 1, so as to open the switch to the road Y. When this is done the detector A can be passed into the slot in the helical element C, and the signal attached to rod K becomes set to "line-clear" so as to allow the train or the like to pass through the switch to the road Y. It will be seen that the switch R R cannot be moved while the signal is "off" or in the "line-clear" position, and that it is necessary that both detectors A A^1 must be withdrawn from helical element C and the signals set "at danger" or "on" before the signalman can move the switch. (*Accepted 17th October, 1907.*)

Semaphores. *6812. 21st March, 1907. J. A. Panton, 42, Ashdale Road, Waterloo, Lancaster.* The arm shown in fig. 1 carries in addition to the coloured spectacles two lamps B C of the straight filament type which are contained in semi-circular reflector cases D, the beadings E of which contain the circuit wires. The positive lead of the upper lamp B is led to the metallic contact piece G, whilst the positive lead of the lower lamp C is led to the contact piece H. The fixed contacts I and J are attached to the post K in such a position that when the arm is raised the red lamp B is illuminated by the contact G engaging the contact I, and and when the arm is lowered the green lamp C is illuminated by the contact H engaging the contact J. In order to limit the two positions of the arm A without shock or jar, which might be detrimental to the lamp filaments, the contact pieces G H are arranged to engage with the plungers L of spring buffers M on the post K. The arm illustrated in figs. 2—5 is arranged to reverse its faces when raised or lowered. For this purpose the spectacle casting is made in two pieces, N O, the arm A being bolted to the piece O. Formed integrally with the casting O is the trunnion P, which is journalled in the casting N and plate O. Keyed on the trunnion P is the bevel pinion R, which meshes with the rack S upon the post K. Consequently as the arm A is raised or lowered the pinion R rotates on the rack S and so the arm is reversed, as indicated in dotted lines in fig. 2. The lamps B and C are





attached on opposite faces of the arm A. The positive lead of the red lamp B is led to the contact piece G, whilst the positive lead of the green lamp C is led to the contact piece H, these contacts being attached in an insulated manner to the casting O. The contacts G H on the arm A engage with fixed contacts I J on the post respectively. The contacts I J possess some elasticity and consequently serve to arrest the movements of the arm A without shock. (*Accepted 17th October, 1907.*)

COMPLETE SPECIFICATIONS ACCEPTED.

1906.

15943. Brakes for tramways and railways. Pringle.
19378. Electric signalling apparatus for use on and in connection with railway locomotive engines and the like. Bounevaille.
22514. Railway Rolling Stock. Canto.
22922. Apparatus used for lighting railway carriages with compressed gas. Haigh.
23516. Railway signalling apparatus. Lake.
24684. Steam superheaters for locomotives and the like. Schwabach.
24902. Means for securing railway rails. Stewart and Richards.
25430. Pipe connections for conveying steam for heating railway trains. Marillier and Pearson.
26858. Operating treadles for railways. Bousfield.
27717. Steam and vacuum brake mechanism for trains and vehicles. Gresham.
28184. Safety holder for keys in railway chairs. Webb.
28278. Automatic block signalling systems for railways. Sayers.
28292. Device for obviating the rattle in the sash windows of railway carriages and the like. McNaught.
28440. Means for preventing derailing of railway vehicles or locomotives. Krimer and Constad.
28929. Means for providing trains with automatic signals. Maynard.
29204. Railway and like signalling systems and apparatus therefor. British Thomson-Houston Co.

1907.

248. Interlocking devices for railway facing points and signals. Smart.
383. Electrically controlled point or switch mechanism for railways. Stoffels.
865. Electro-magnetic brakes for railway and like vehicles. Schaake.
1430. Brakes for railway vehicles. MacPherson.
1455. Condensation system applicable to locomotives. Gadda and Beluzzo.
1898. Appliances for operating points and signals on railways and tramways and for other purposes. Taylor.
2048. Brakes for railway and like vehicles. Simpson.
3768. Brake apparatus for railway wagons and other similar vehicles. Parrott.
3925. Devices for catching and holding up the handles of railway wagon and like brakes. Simpson.
5251. Mechanism for operating the discharging doors of railway wagons. Morgan and Metropolitan Amalgamated Railway Co.
5548. Apparatus for electrically operating and controlling semaphore signals. Siemens Bros. and Co. and Ferreria.
5661. Couplings for railway vehicles. Thomas.
6812. Railway signal semaphores. Panton.
7527. Railway signalling apparatus. Raven.
8278. Spark arrester. Liechty.
9097. Automatic railway coupling. Wolf and Pfander.
9439. Semaphore signals. Abernethy and Weiss.
10344. Automatic railway and the like couplings. Ulbrich.
10916. Sleepers and means for attaching railway rails thereto. Beal.
13035. Rail joints. Wolhaupter.
13816. Fastening and unfastening of doors of railway wagons and like vehicles. Bowles.
13828. Automatic fluid-pressure brakes for railway and like vehicles. Turner.
15464. Manufacture of axle guards for railway carriages, wagons and like vehicles. Bamber.
15929. Rail joints. Fenn.
16479. Device for automatically locking doors of railway cars whilst the train travels. Mittmann.
18568. Railway wagons and like vehicles. Bowles.

The Locomotive from Cleaning to Driving.—XIII.*

By

JOHN WILLIAMS, *Locomotive Inspector Great Central R.*, and JAS. T. HODGSON, *Mechanical Superintendent School of Technology, Manchester.*

[NOTE.—Owing to some of the illustrations not being ready it was impossible to continue the subject of Brakes in this issue, but we shall do so in our next.—Ed. R.E.]

Speed Indicators.

NOTWITHSTANDING the high degree of proficiency with which an experienced driver may instinctively estimate the speed at which his engine is travelling, it is indisputable that the use of a reliable automatic speed indicator or recorder would tend to eliminate the fallible human factor, and thus reduce the risks of derailment or other accidents caused by excessive speed when passing through points and crossings or round sharp curves, etc. It is also obvious that the means of accurately estimating the rate of movement during the hours of darkness or fog, for instance, are far less reliable than when daylight or clear atmospheric conditions prevail. If, therefore, the driver could assure himself as to the rate at which he was travelling by simply referring to a speed indicator he would be enabled to run with greater confidence and at the same time devote the whole of his attention to the look out for signals, etc., ahead.

In France the Government has decided that Tachographs (recording speed indicators) are essential for the safety of railway passengers, and have in consequence ordered all French railway companies to equip every passenger engine with such instruments within a stated period.

The speed indicator and recorder (Flaman's patent), fig. 37, is now adopted on the State and principal private railways in France. The mechanism of the Tachograph is contained in an iron box hermetically sealed and placed inside the cab in full view of the driver.

A semi-circular scale graduated in miles per hour is fitted in the upper portion of the instrument, the speed being indicated by a pointer connected to the recording mechanism, and the speed limit allowed is denoted by a movable pointer, which may be set from the outside of the case.

The pointer on the small circular time dial is arranged to make one complete revolution every ten minutes, and the face is sub-divided into forty divisions, each of which, therefore, correspond to fifteen seconds.

The paper on which the speeds are marked is made to unwind from the spools at a rate of movement exactly proportionate to the distance covered on the rail, and the time is

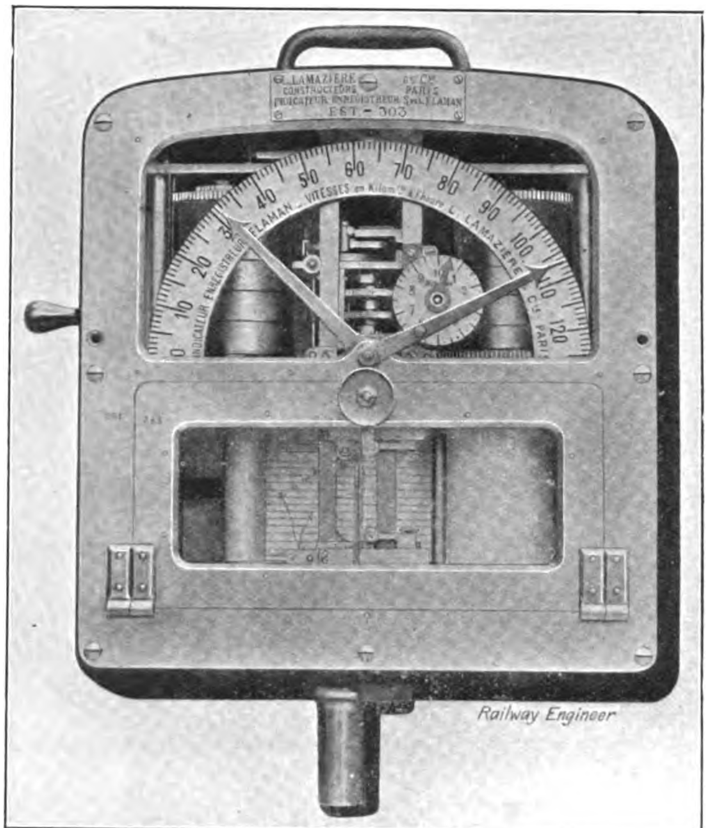


Fig. 37.

also simultaneously recorded on the upper portion of the speed chart, thus giving in addition to the speed the location and duration of any stops that may be made.

*Copyright. No. I. of this series appeared in February, 1907; No. II. in March, 1907; No. III. in April, 1907; No. IV. in May, 1907; No. V. in June, 1907; No. VI. in July, 1907; No. VII. in August, 1907; No. VIII. in September, 1907; No. IX. in October, 1907; No. X. in November, 1907; No. XI. in December, 1907; No. XII. in January, 1908.

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Figs. 38 and 39 represent a front view and a sectional plan of the Tachograph, showing the general arrangement of gears, with the parts tabulated as indicated by the reference letters on the drawing.

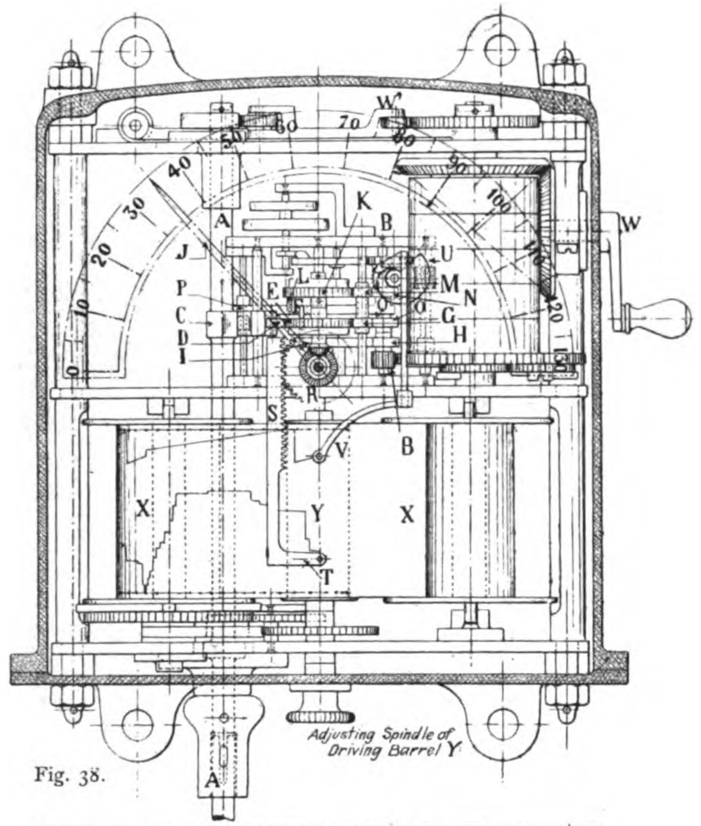


Fig. 38.

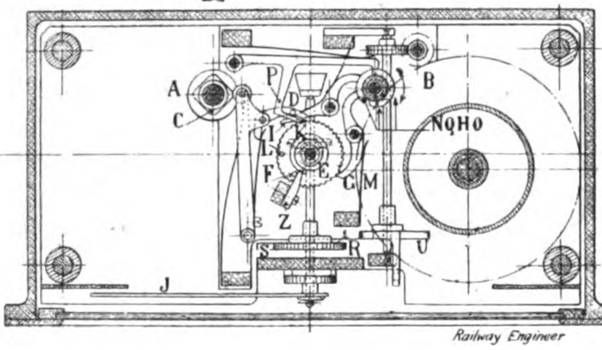


Fig. 39.

A—Main driving spindle of tachograph.
B—Escapement shaft of clockwork.
C—Driving cam for pawl.
D—Driving pawl of ratchet wheel measuring speeds.
E—Ratchet wheel measuring speeds.
F—Stud on wheel E.
Z—Fixed stop determining position of ratchet wheel at rest against the stud F.
G—Stop-pawl of ratchet E.
H—Cam to ungear the pawl D of the ratchet E at end of periods of speed-measure.
I—Lever actuated by cam H to ungear the pawl D.
J—Indicator hand of tachometer.
K—Ratchet wheel transmitting to hand J the angular displacement of ratchet E.
L—Stud on lower face of ratchet K serving to determine its angular position against the stud F of wheel E.
M—Stop-pawl of ratchet wheel K.
N—Cam actuating stop-pawl M of ratchet K.
O—Cam actuating stop-pawl C of rachet E.
P—Lever for gearing the pawl D with the wheel E at commencement of each period of time.
Q—Cam actuating lever P.
R—Tooth sector solid with hand J.
S—Rack transforming circular movement of speed hand into a vertical motion of which the ordinates are proportional to speeds.
T—Speed-recording style.
U—Spiral cam actuated by clockwork for registering the times.
V—Time-recording style actuated by cam U.
X—Paper band for receiving speeds, times, distances and stop durations.
Y—Driving barrel for paper band the needle points of which perforate the paper at intervals corresponding to 1 kilometre.
W—Hand-key for winding up clock.
W'—Automatic clock winder operated by the movement of the locomotive.

The instrument may be mounted on any type of locomotive without modification and is shown in fig. 40 as fixed with a transmission gear composed of a single set of bevel pinions.

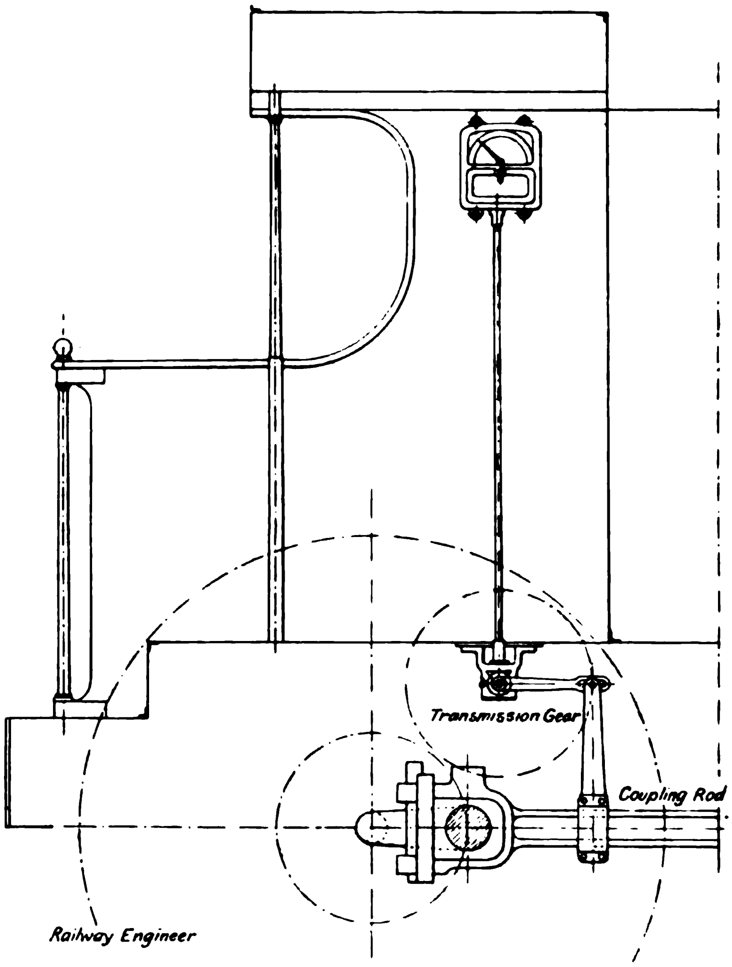


Fig. 40.

Drivers' Duties (continued).

In looking ahead to see that the section is clear a strict watch should be maintained on the opposite running line, in order that it may be properly protected according to rule should any obstruction or fault be seen. The driver should also look back from time to time, especially when passing through junctions or curves, etc., to see that the train is following intact. When shunted across the road or into a siding with a train the driver should take notice that he has not been backed again on the same line by the signalman inadvertently failing to remove the points, and when re-crossing the road it should be seen that the train has been turned on the proper running line.

Various details affecting the cleanliness of the engine will be gradually acquired; the number of black patches on the boiler, for instance, will be greatly reduced by avoiding the use of the large ejector (unless absolutely necessary) when standing or passing under bridges. By measuring his water from time to time, noticing the quantities of coal consumed, taking into consideration the geography of the road, number of vehicles on the train, and the condition of his engine, the driver will soon be able to form a fairly accurate idea as to the distance he can travel with a given amount of water and coal.

The methods of procedure when starting away with a passenger or other train, manipulation of the brakes when running down a falling gradient, and regulation of speed when entering a terminus, etc., have already been described elsewhere.

The engine should be returned to the shed with the fire as low as possible, so that it may be dropped if necessary after a proper supply of coal, water, and sand has been obtained. The boiler should also be filled before the fire is dropped, so that the cooling process may be gradual, thereby reducing the chances of damage by sudden or violent contraction.

Anything of an unsatisfactory nature that may have been observed in the running of the engine during the journey should be at once seen to. If the engine has been steaming badly, for example, the smoke-box should be inspected for leaky joints and the pipes tested by admitting steam. If all joints are found tight and the brick arch is in good condition a faulty piston may be causing the trouble. This is often indicated by the tube ends in the fire-box becoming choked with dirt, and if any doubt occurs the pistons should be at once tested.

If the beats of the engine have been very irregular, or a constant blow up the chimney observed, and there is the least suspicion that something is wrong with the admission or exhaustion of steam to and from the cylinder the valves should also be tested. The following is a simple method whereby the tests for faulty valves or pistons may be carried out.

First place right-hand crank on top centre with the reversing lever in full forward gear, brake hard on, and cylinder drain cocks open. With crank and lever in this position steam will be admitted to the back end of the cylinder when the regulator is opened. If the piston rings are leaky or broken, steam will be discharged from both drain cocks, but if the rings are good and tight, steam will issue from the back drain cock only. To make sure, the lever may be placed in mid gear when the valve will be in its middle position with both steam ports closed, and the drain cocks should therefore be free from steam. Then place the lever in full backward gear, thus admitting steam to the front end of cylinder and through the front drain cock only if the piston rings are in good condition. If a blow from the drain cocks is observed with the lever in mid gear it may be taken for granted that the valve is faulty or the valve lap broken. The end of the cylinder from which the steam issues will denote whether it is the front or back valve lap that is damaged. If a small piece only is broken from the lap the constant blow will be observed when running in full fore or full back gear, but will disappear entirely when notched up to near mid gear.

With the crank on top centre it will be seen that the valve always travels in the same direction as the reversing lever and that steam is admitted to the front end of the cylinder with the lever in full back gear, and back end of cylinder with lever in full fore gear. If, however, the piston is tested with crank on bottom centre the reverse takes place, and the valve will travel in the opposite direction to the reversing lever. In this case steam will be admitted to front end of cylinder with lever in full fore gear or back end of cylinder with lever in full back gear, and the steam from the drain cocks must be noted accordingly. These tests may, of course, be carried out with the cranks in different positions to those here given, but the foregoing is quoted as a very simple and effective method whereby each engine may be tested separately.

Erratic or constant blows up the chimney may also be given from other causes than those already mentioned. A strained or broken valve spindle or buckle, for instance, may give either an erratic or a continuous blow, as by the adjustment of the valve being altered, the valve held from its face, or a steam port continuously open, according to the nature of the failure. The shifting of an eccentric or a break in the division between the steam and exhaust ports will also give an erratic beat. In the latter case a heavy blow will be given up the blast pipe when the damaged port is opened to steam by the valve. A broken valve cavity would give a continuous blow up the blast pipe immediately the regulator was opened. These last failures are, however, of rare occurrence, and a broken valve cavity would completely disable the engine by the great loss of steam, and assistance would therefore have to be obtained as provided for in the rules

To locate a faulty beat or blow it is essential that the driver should possess a knowledge of the relative crank and valve positions. In accordance with the usual method of setting and for simplicity the writers have hitherto strictly adhered to the relative positions of valves with cranks on centres.

Since, however, examiners may require a candidate to have some knowledge of relative positions with cranks on angles, it is important that the rising driver should be familiar with valve events in these different positions, in order to be prepared for the passing of his examination.

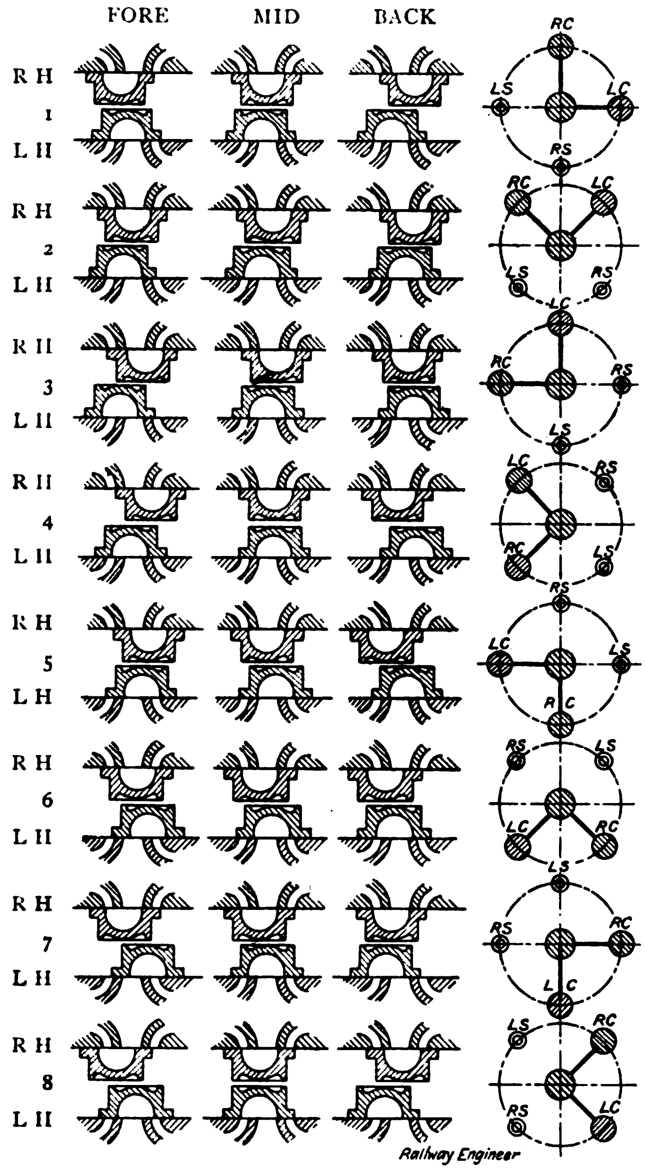


Fig. 41.

The diagrams, figs. 41 and 42, should therefore be of assistance in the acquisition of the necessary information as to the relative positions of cranks, valves and side rods with Stephenson's link motion on both centres and angles, for engines with either right or left-hand leading cranks.

Fig. 41 gives relative positions on centres and angles for an engine with *right-hand crank leading*.

(1) R. and L.H. big ends on top and back centres respectively, with lever *in fore gear*. Both front ports open to exhaust, with R.H. back port open to steam and L.H. back port, by amount of lead only.

In mid gear, the R.H. front and back ports are closed, since the valve is in middle position, with L.H. front port open to exhaust and the back port to steam by amount of lead only.

In back gear, the R.H. back and L.H. front ports are open to exhaust, with R.H. front open to steam and L.H. back by amount of lead only.

(2) R. and L.H. big ends on top front and top back angles respectively with *lever in fore gear*—R. and L.H. front ports open to exhaust; R.H. back port closed and L.H. back open to steam.

In mid gear, the R.H. front and L.H. back steaming edges of valves and ports are about in line, with R.H. back and L.H. front open to exhaust.

In back gear, both back ports are open to exhaust, with R.H. front open to steam and L.H. front port closed.

(3) R. and L.H. big ends on front and top centres respectively with lever *in fore gear*. The L.H. back and R.H. front ports open to steam, the latter by amount of lead only, with R.H. back and L.H. front ports open to exhaust.

In mid gear, the L.H. front and back ports are closed since the valve is in middle position, with R.H. front port open to steam, by amount of lead only and back port open to exhaust.

In back gear, both back ports are open to exhaust and both front ports open to steam, the R.H. by amount of lead only.

(4) R. and L.H. big ends on bottom front and top front angles respectively, with lever *in fore gear*. The R.H. back and L.H. front ports open to exhaust, with R.H. front open to steam and L.H. back port closed.

In mid gear, both front steaming edges of valves and ports are about in line, with both back ports open to exhaust.

In back gear, the R.H. front and L.H. back ports are open to exhaust, with L.H. front open to steam and R.H. back port closed.

(5) R. and L.H. big ends on bottom and front centres respectively, with lever *in fore gear*. Both back ports open to exhaust and front ports open to steam, L.H. by amount of lead only.

In mid gear, the R.H. front and back ports are closed since valve is in middle position, with L.H. back port open to exhaust and front to steam by amount of lead only.

In back gear, the R.H. front and L.H. back ports are open to exhaust, with R.H. back port open to steam and L.H. front by amount of lead only.

(6) R. and L.H. big ends on back and front bottom angles respectively, with lever *in fore gear*. Both back ports are open to exhaust, with L.H. front open to steam and R.H. front port closed.

In mid gear, the R.H. back and L.H. front steaming edges of valves and ports are about in line, with R.H. front and L.H. back ports open to exhaust.

In back gear, both front ports are open to exhaust, with R.H. back open to steam and L.H. back port closed.

(7) R. and L.H. big ends on back and bottom centres respectively, with lever *in fore gear*, R.H. front and L.H. back ports open to exhaust, with L.H. front open to steam, and R.H. back by amount of lead only.

In mid gear, the L.H. front and back ports are closed since the valve is in middle position, with R.H. front open to exhaust and back port to steam by amount of lead only.

In back gear, both front ports are open to exhaust with back ports to steam, R.H. by amount of lead only.

(8) R. and L.H. big ends on top and bottom back angles respectively, with lever *in fore gear*. R.H. front and L.H. back ports open to exhaust, with R.H. back open to steam and L.H. front port closed.

In mid gear, both back steaming edges of valves and ports are about in line, with both front ports open to exhaust.

In back gear, the R.H. back and L.H. front ports open to exhaust, with L.H. back open to steam and R.H front port closed.

Fig. 42 gives relative positions of cranks, valves and side rods for an engine with left-hand crank leading.

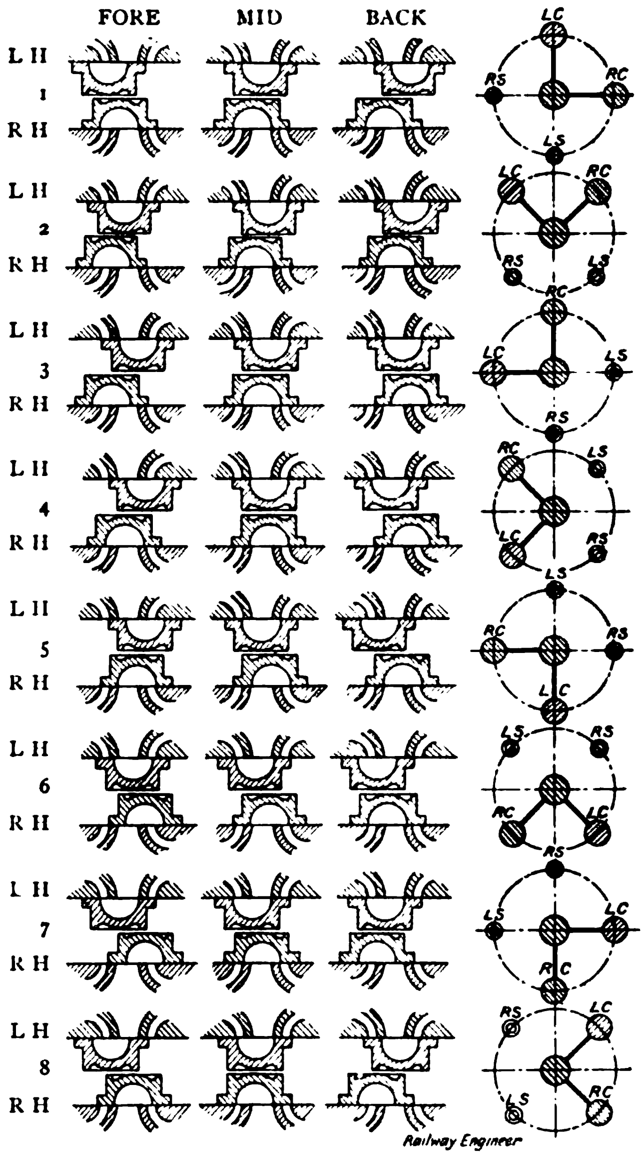


Fig. 42.

(1) L. and R.H. big ends on top and back centres respectively, with lever *in fore gear*. Both front ports open to exhaust and back ports open to steam, R.H. by amount of lead only.

In mid gear, the L.H. front and back ports are closed since the valve is in middle position, with R.H. front port open to exhaust and the back to steam, by amount of lead only.

In back gear, the L.H. back and R.H. front ports are open to exhaust, with L.H. front open to steam and R.H. back by amount of lead only.

(2) L. and R.H. big ends on top front and top back angles respectively, with lever *in fore gear*. Both front ports open to exhaust, with R.H. back open to steam and L.H. back port closed.

In mid gear, the L.H. front and R.H. back steaming edges of valves and ports are about in line, with L.H. back and R.H. front ports open to exhaust.

In back gear, both back ports are open to exhaust, with L.H. front open to steam and R.H. front port closed.

(3) L. and R.H. big ends on front and top centres respectively, with lever *in fore gear*. The L.H. back and R.H. front ports open to exhaust, with R.H. back open to steam and L.H. front by amount of lead only.

In mid gear, the R.H. front and back ports are closed since the valve is in middle position, with L.H. back open to exhaust and front port open to steam by amount of lead only.

(4) L. and R. H. big ends on bottom and top front angles respectively, with lever *in fore gear*. The L.H. back and R.H. front ports open to exhaust, with L.H. front open to steam and R.H. back port closed.

In mid gear, both front steaming edges of valves and ports are about in line and back ports open to exhaust.

In back gear, L.H. front and R.H. back ports open to exhaust, with R.H. front port open to steam and L.H. back port closed.

(5) L. and R.H. big ends on bottom and front centres respectively, with lever *in fore gear*. Both back ports open to exhaust, and front ports to steam R.H. by amount of lead only.

In mid gear, the L.H. front and back ports are closed since the valve is in middle position, with R.H. back open to exhaust and front port to steam by amount of lead only.

In back gear, the L.H. front and R.H. back ports are open to exhaust, with L.H. back open to steam and R.H. front by amount of lead only.

(6) L. and R.H. big ends on bottom back and bottom front angles respectively, with lever *in fore gear*. Both back ports are open to exhaust, with R.H. front open to steam and L.H. back port closed.

In mid gear, the L.H. back and R.H. front steaming edges of valves and ports are about in line, with L.H. front and R.H. back ports open to exhaust.

In back gear, both front ports are open to exhaust, with L.H. back open to steam and R.H. back port closed.

(7) L. and R. H. big ends on back and bottom centres respectively, with lever *in fore gear*. L.H. front and R.H. back ports open to exhaust, with R.H. front open to steam and L.H. back by amount of lead only.

In mid gear, the R.H. front and back ports are closed since the valve is in middle position, with L.H. front open to exhaust and back port open to steam by amount of lead only.

In back gear, both front ports are open to exhaust and back ports to steam, L.H. by amount of lead only.

(8) L. and R.H. big ends on top and bottom back angles respectively, with lever *in fore gear*. L.H. front and R.H. back ports open to exhaust, with L.H. back open to steam and R.H. front port closed.

In mid gear, both back steaming edges of valves and ports are about in line, with front ports open to exhaust.

In back gear, the L.H. back and R.H. front ports open to exhaust, with R.H. back open to steam and L.H. front port closed.

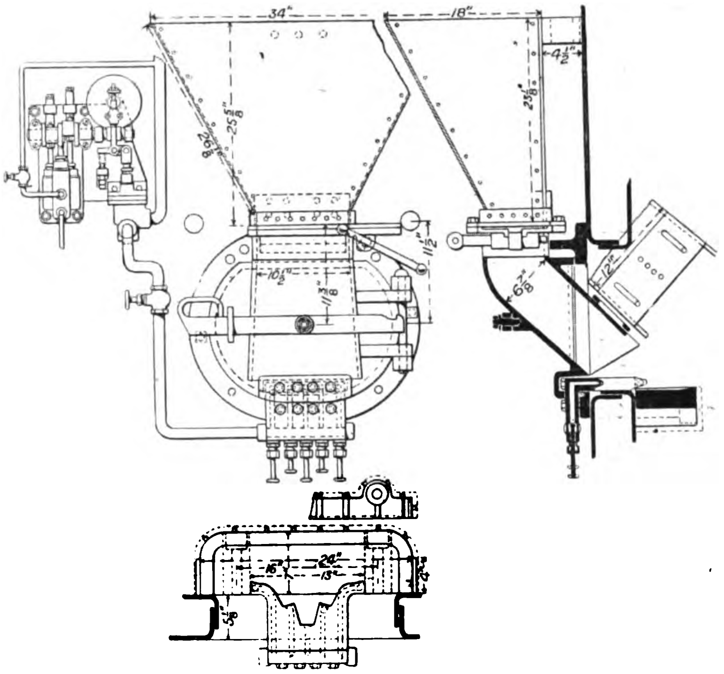
Assuming that nothing unusual has been observed during the journey, and a supply of coal and water obtained, the engine should be placed over a pit with the right-hand crank on the bottom centre, brake hard on, cylinder drain cocks open, and a lever in mid gear for a thorough and systematic examination. The driver should then leave the footplate on his own side and pass round the engine and tender with his right hand nearest the motion work. All tyres should be sounded with the hand hammer, and side rods, axle boxes, springs, brake hangers, shackles, etc., closely inspected. Passing underneath the brake and sanding gear, big and little ends, axles, eccentrics, straps, and rods, slide bar bolts, and glands, etc., should be closely examined. Pass under ash-pan to inspect damper rods, and brake gear under footplate, etc., and see that the hose connections are uncoupled in frosty weather.

The cranks should afterwards be moved to the top position, *i.e.*, equidistant from the top centre, so that the big ends, etc., will be well out of the way when raking out the ashes. Any defect, however trifling, should be carefully noted and entered in the repair book. Reports as to loss of time, the state of the road, etc., are most effective when to the point, and will be more fully appreciated by the head of the department when clearly and concisely written.

(To be continued.)

The Hayden Locomotive Stoker.

The Hayden stoker differs from other mechanical stokers in being provided with a conveyor which delivers the coal from the tender to the hopper at the fire door, and instead of having mechanical plungers for forcing the coal into the firebox this work is done by means of a steam jet. The accompanying illustrations will serve to show the mechanical arrangement of this stoker and of the conveyor. The stoker proper consists of a narrow shelf which is bolted in the firebox even with the bottom of the door opening, and this receives and supports the column of coal. The fire door that is substituted for the old door is constructed with a chute leading to it and is hinged on the flame in the usual manner. Above the chute is a hopper to receive the coal, and this is bolted to the boiler head. The hopper leads directly into the chute, but no solid connection is made, and the fire door can be opened and closed in the usual manner. In the lower portion of the hopper is a slide which may be opened and closed so that the fuel supply may be cut off in case it is desired to fire by hand. A blast pipe consisting of a series of jets is placed in the bottom of the fire door opening, which is just behind the shelf, and they are directed in such a manner as to throw the fuel to all parts of the grate. Each jet is provided with a valve so that the flow of steam through it may be regulated independently of the flow through other jets. These valves are mounted on a manifold which is connected by a pipe to the blast valves. The globe valve placed

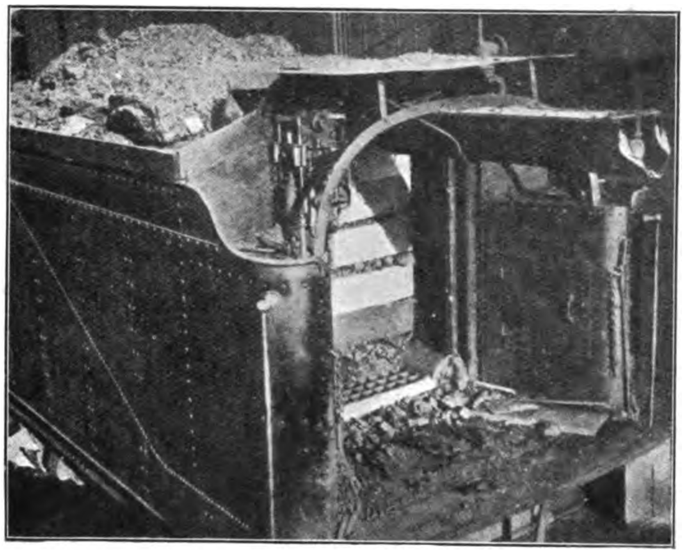


Hayden Locomotive Stoker.

in this pipe controls the force of the blast as a whole. An instantaneous opening and closing of the blast is required, and the blast valves are constructed for this purpose. They consist of a main valve and an auxiliary valve and the proper ports combined in a casing so that a slight movement of the auxiliary operates the main valve instantaneously through its full movement. The main valve has a differential piston, the large head being above and connected to a small head below. The auxiliary valve is connected to a bell crank lever and an adjustable trip finger carried on a revolving disc rocks the lever on its pivot, thereby opening the auxiliary valve. A spring in compression connects the lever and auxiliary valve and holds it normally in a closed position. The disc carrying the trip finger is revolved by a small engine, which may be throttled to give the desired speed for the number of blasts required.

The conveyor is placed between the bulk heads of the tank with the lower part flush with the bottom of the coal space, and is constructed with a series of buckets mounted

on an endless chain and surrounded by a casing. The travel on the buckets lifts the coal vertically and pumps it in a horizontal trough that extends forward to the hopper on the boiler head and high enough to clear the fireman. In this trough a spiral conveys the coal to the hopper. The coal inlet at the bottom of the vertical conveyor is covered by a grate having an opening three inches square, and the coal is raked into these openings. The conveyor is driven by a small steam engine which is conveniently mounted on the tender and is controlled by a throttle valve located on the engine. The operation of the stoker is as follows: The coal being fed into the hopper from the conveyor falls by gravity through the chute in the door and rests in a pile upon the shelf in front of the jets. The size of the pile of coal on the shelf is determined by the position of the plate at the mouth



View of Conveyor on Tender.

of the chute. The coal being fed continuously through the hopper and chute forms an air seal and preserves a draft in the furnace. The jet valves are throttled so that when the blast operates the fuel is thrown to all parts of the furnace and scattered freely over the fire. The globe valve in the main steam pipe is set so as to give the proper force to the blast as a whole according to the draft of the furnace. Steam under pressure is supplied to the nozzles by the operation of the blast valves. The trip finger operates the auxiliary valves by means of the bell crank, which is adjustable, so that this valve may be held open for a varying period of time, thus controlling the duration of the blast. If a furnace has two fire doors the blast is admitted alternately and a duplex blast valve is arranged for this type of furnace, the bell cranks being operated alternately by the trip finger. This allows a portion of the fire to remain in an incandescent state while fresh fuel is supplied to the other part of the furnace, and the alternating firing in this way reduces the amount of smoke from the stack. The stoker at one door can be entirely discontinued in order to clean the fire, while that at the other door continues in operation. This stoker has been in successful operation for nearly a year on a consolidation engine having cylinders 22 by 32, driving wheels 62 inches, tractive power 49,960 pounds, total heating surface 3,358 square feet, grate 104 inches long and 75 inches wide, giving an area of 54 square feet. The tender has a capacity of 6,800 gallons of water and 14 tons of coal.

At the recent meeting of the travelling engineers in Chicago this stoker was reported as operating very satisfactorily by representatives of the Erie road. The N. S. Hayden Manufacturing Company, of Columbus, O., which has spent a large amount of money in experimental work connected with this stoker, deserves the thanks of the railroads for its persistent effort in developing a successful mechanical stoker for locomotives.—*The Railway Age.*

Derailments at a Diamond Crossing

It may be remembered that early in the morning of March 12th, 1906, a derailment took place at Stafford on the L. and North Western R. at a diamond crossing, and Col. Yorke in his report on the accident (*Railway Engineer*, October, 1906, p. 331, Vol. XXVII.) said that "appliances have, from time to time, been tried to abolish the risk and to render such crossings safe. Of such, the best-known are (1) diamond point protectors, which have been used with, I believe, satisfactory results in a few places, and (2) moveable diamonds or switch diamonds, which are common enough in America and are in use to a limited extent in England."

The diamond point protector referred to in the Board of Trade report is evidently that made by Henry Williams, Ltd., and which is in use on eight or ten railways, particularly on the Glasgow and South Western R.—there are 16 in St. Enoch's Station alone—and on the northern division of the North Eastern R. After trying one for some time in Liverpool Street Station the Great Eastern R. have recently put several down in that yard.

Fig. 1.

A photographic view of the Williams protectors is given in fig. 1 and a diagram in fig. 2. It will be seen that in the gap between the wing-rails and the point of the crossing there are wedges, a a^2 b b^2. Of these, a and b^2 are coupled together and a^2 and b, but they are each connected differently,

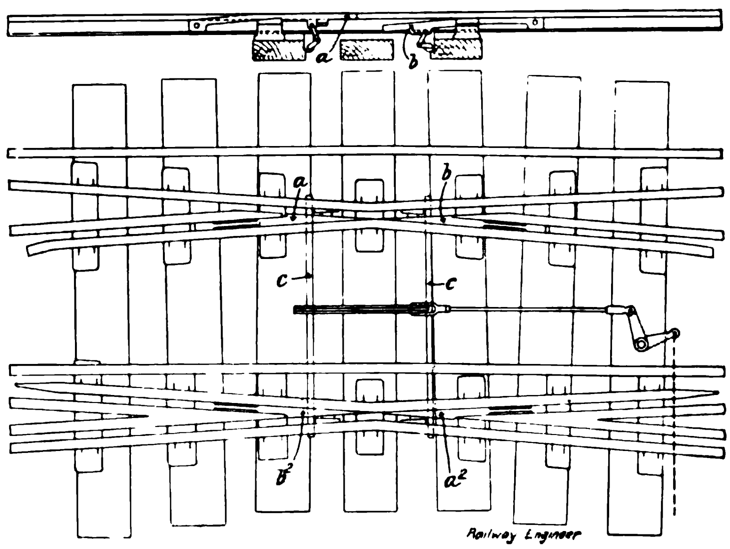


Fig. 2.

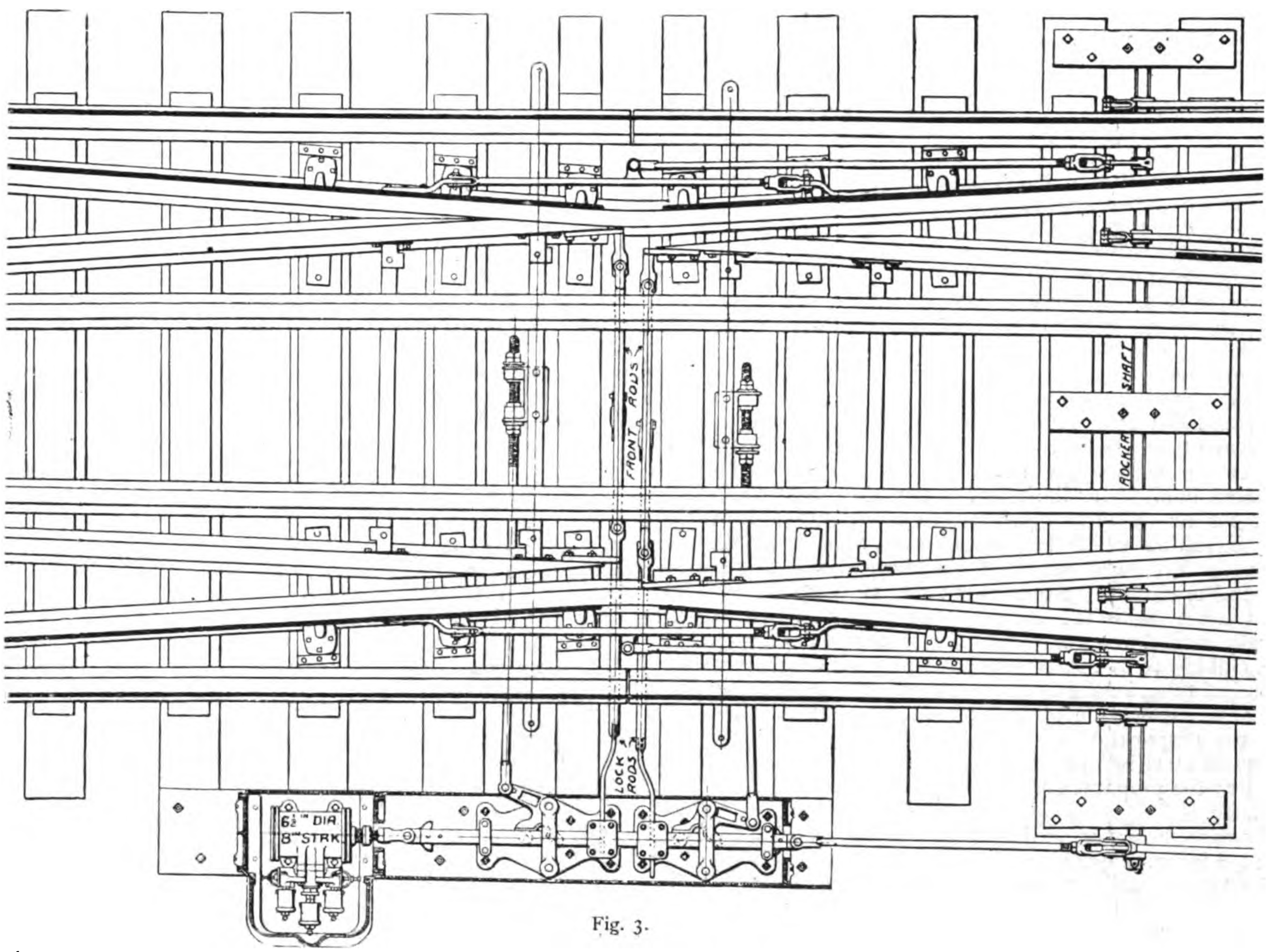


Fig. 3.

as a rises when b^2 falls, and consequently a and a^2 are up together and b and b^2 similarly. Each pair are operated by the rocker shaft, c, which is connected to the point rodding operating the switches. As seen in fig. 2, the road is set for a train to travel from the upper left-hand corner to the lower right-hand, or *vice versa*, and therefore wedges a and a^2 are both raised so as to keep the flanges of the wheels in line. When the road is set between the lower left-hand and the upper right-hand the wedges b and b^2 are raised and a and a^2 lowered. The pressure of the wheels comes on the sides of

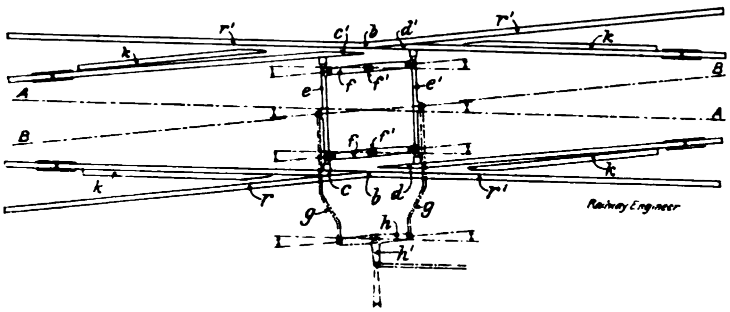


Fig. 4.

the wedges and not on the tops and it is transmitted to the wing-rails.

Fig. 3 shows a diamond crossing—or double slip switch with moveable frogs—as laid down in America. It is shown connected to an electro-pneumatic signalling frame and provided with locking bars.

At Victoria Station, L., Brighton and S.C.R., there are fixed in the outlet from the carriage sidings some of the Sykes and Howard's patent diamond crossing. These are illustrated by fig. 4. The switches c and c^1 work together and d and d^1, and all four are shifted by one rod from the signal-box. Abutment rails k k k k are provided and fixed in chairs in the usual way, and against these the moveable switches bear, and consequently the gauge is rigidly maintained.

It is necessary to equip both sets of switches with facing point locks and locking bars if they be fixed in a running line. The arrangement is manufactured by the W. R. Sykes Signal Interlocking Co.

The Manufacture and Upkeep of Milling Cutters.*

By
Dr. H. T. Ashton, *of Royal Small Arms Factory, Enfield Lock.*

Although the system of manufacture of milling cutters detailed in this paper is suitable for general application, it has been developed more particularly to meet the difficulties of extending the use of high-speed steel to milling cutters of complicated shape, required when cutting to give an accurate finish and a good surface. It is believed that these difficulties have been commonly met with, and that owing to them the general introduction of high-speed steels of the Taylor-White class has, so far, generally proved of less benefit to engineers for milling cutters than for any other form of cutting tool used in engineering workshops.

Perhaps the advantages to be obtained by the use of high-speed steels for such cutters are also not so obvious as they are for the heavy lathe or planer tools, where the almost red-hot chips, that they can be made to produce, appeal to the least observant onlooker. When, however, it is considered that this class of steel not only has the property of keeping a

*Read before the Institution of Mechanical Engineers

cutting edge for a reasonable time when taking very heavy cuts at a previously unattainable speed, but also keeps its cutting edge when used with a moderate cut and speed for a far longer period than was previously obtainable, its advantages, if applicable to complicated milling cutters, are clearly just as great as for the simpler tools taking the heavy cuts. For, although the nature of the work upon which the cut is taken and the finish required from the cut may not allow, in the case of the milling cutter, any great increase of speed or feed by the use of high-speed steel, and consequently little direct saving upon the time occupied in dong the work, as in the cases of the other classes of tools, yet an equally important saving is effected upon the cost of supply of the tools themselves. The milling cutter is the most expensive of all the tools used by engineers in cutting metals. In the simplest milling cutter the cost of workmanship so largely exceeds the cost of material that a moderate increase of life obtained by improvements in the raw material far outweighs a considerable increase in its original cost, provided that there is sufficient work in sight for the cutter to ensure its being fully employed for its maximum possible life. Perhaps it is this ruling condition which has led to somewhat less attention being paid to the application of these steels to milling cutters in general engineering workshops than to other cutting tools. For in these, with the exception of a few simple cutters generally useful for roughing out or for finishing simple profiles likely to recur, it has perhaps generally been more economical to make the cutters from ordinary qualities of tool steel, or even in some cases from case-hardened mild steel; hence the preparation of an elaborate milling cutter from high-speed steel has not received quite the same general attention as the preparation of other cutting tools of maximum endurance.

The case, however, is different in a number of workshops where the interchangeable parts of many classes of apparatus and fittings depend very largely upon the use of formed milling cutters, and where the accuracy of the work so produced is directly dependent upon the accuracy with which the form of the cutter can be maintained for a prolonged period. It is desirable also that the cutters should have as long a life as possible in actual service, not only to minimise the first cost and upkeep, but also to keep the output of the machines as continuous as possible, by reason of freedom from delays in changing the cutters. These points depend chiefly upon :—(1) The quality of steel from which they are made; (2) the method of hardening adopted; (3) the care and accuracy with which the new cutters are made; (4) the facility and correctness with which the cutters can be ground up when they have become dull or lost their accuracy.

(1) *The Steel used.*—There is, of course, nothing to compare with the recently developed high-speed steels as a material for cutters which are required to work at a high cutting speed and have the maximum possible life; and no difficulty is now experienced in obtaining work with a sufficiently satisfactory finish, provided care is exercised in the grinding and finish of the cutters, in the manner which will be described, and also if the cutting speeds and feeds are suitably arranged. Any of the best-known makes of this class of steel can be used in conjunction with the system to be described.

The milling cutters are annealed, packed in spent powdered charcoal and steel turnings in cast-iron pans with covers which are luted down. These are placed in the annealing furnace first thing in a morning and are gradually heated up to 700° C. to 750° C.; this heat is usually reached by 1 o'clock and is maintained until about 5 o'clock, when the dampers are closed and the furnace is allowed to cool gradually for forty-eight hours. It is found that some makes of high-speed steel are satisfactorily annealed by the makers, but it is not the universal practice. Annealing in this manner is found to give thoroughly satisfactory results.

(2) *Method of Hardening.*—The furnace used for hardening cutters is shown in fig. 1, and it has been found specially adapted for obtaining a soaking heat, together with the high temperature necessary in treating this class of steel and freedom from oxidation. The furnace is coke fired and has a forced draught, and temperatures up to 2,300° F. can be obtained.

In using the furnace the cutters are packed closely in powdered charcoal in sheet steel boxes about 6ins. by 6ins. by 3ins. These boxes take from $2\frac{3}{4}$ to 3 hours to reach the necessary hardening temperature, the time taken varying with the weight of metal to be heated. The hardening temperature varies somewhat according to the class of steel being used, but may be said to be between 2,000° F. and 2,100° F. The exact temperature necessary for satisfactorily hardening any particular class of steel is previously determined in the laboratory by exact experiments, and the temperatures obtained in the furnace are checked by means of a Fery Radiation Pyrometer. This pyrometer is itself tested against a standardised Callendar pyrometer, and has so far been found to give extremely reliable results.

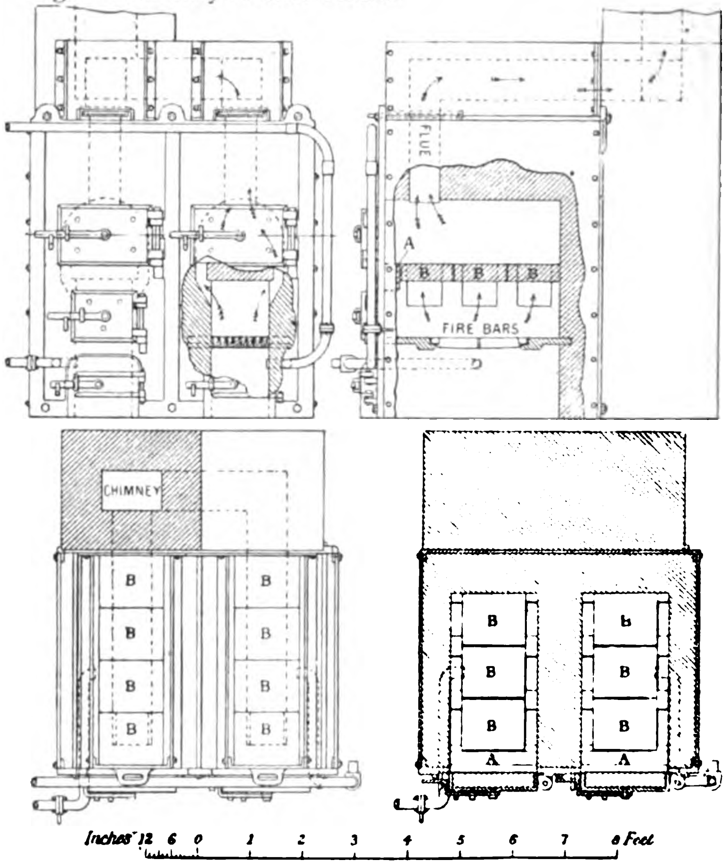


Fig. 1.

The cutters when sufficiently heated are quickly removed from the charcoal in which they have been packed, and are at once placed upon the hardening table. This table is of a type frequently used in workshops for heating tools by gas, but when used for hardening cutters air only is supplied through the two nozzles. These can be moved as required about vertical pivots so as to cause the air-blast to impinge upon the periphery of the cutters at any required points and simultaneously upon the vanes of the spindle upon which the cutter is placed, causing the whole arrangement to rotate and thus equalising the cooling and hardening effect. The air delivered upon the cutter is drawn from an old culvert which passes under the floor of the workshop and through which a stream of water continually flows; hence at all times of the year a supply of cold damp air of maximum cooling effect is available. The temperatures used in hardening are such that the edges of the cutters are almost fused, and although different makes of steel have been found to vary somewhat in this respect, the general statement remains true of all of them. At the same time it is found that this fusing effect for a given heat is considerably minimised by the method of heating in closed boxes as compared with the ordinary method of

heating tools, either in a muffle or in a direct gas-flame, and even the scaling, which with the latter systems is frequently very marked, is with the method now described so slight that the cutters can be wholly freed from scale by placing momentarily under a revolving scratch brush.

All difficulties as regards the expansion of the hole through the cutters in hardening are met initially, leaving the bore slightly smaller than is ultimately required—on the average about 0·01 inch less than the finished diameter; the expansion is usually about 0·003 inch to 0·005 inch, the average diameter of the mandril being 1 inch. After hardening, the milling cutters are first chucked truly with the outside diameter in a self-centring chuck, and the internal bore is ground up truly to the finished diameter. After this the hardened cutters are chucked upon mandrils and the teeth are finished upon the special machines to be described.

(3) *Forming Cutter Teeth.*—Accuracy of form of the cutters is secured, both when being cut in the first place and also subsequently reformed, by turning the blanks and milling out the teeth in the ordinary manner, and then backing them off in a machine in which the blank to be formed is carried on a dividing head, so that one tooth at a time can be presented to a small milling cutter. This is mounted upon a cutter spindle driven by a pulley, from which cat-gut cord runs through an overhead gear, allowing the spindle to be moved within the necessary limits. The small cutter spindle-frame forms part of a system of adjustable pantograph links, so that its movement is an exact reproduction in miniature of the movement of the tracing pin upon a former fixed in front of the machine. The operator, by means of a handle, moves a pin lightly along the former, and consequently also moves the cutter over the tops of the teeth to a similar but smaller shape. The small cutter is enlarged in diameter towards one end, so that it cuts away the back of each tooth upon the cutter to the necessary extent. Commonly a conical backing-off cutter is used, the angle of the cone being 20° and the setting being such as to give an angle of relief of 10°, that is, the axis of the cone is at right angles to the radial face of the tooth being backed off. It will be seen that this characteristic enables the machine to produce teeth of any form, upon a cutter backed off in every direction from the cutting edge, so that a clean cut can be taken with the sides as well as with the tops of the teeth.

In the case of those milling cutters in which grinding back the faces of the teeth so backed off might cause serious inaccuracy, owing to its throwing back the radial cutting edges of the teeth, the cutters are built up of annular sections which are either clutched together or clamped together upon plain faces, from which, after a particular grinding or series of grinding operations, the same amount is ground off as that by which the radial cutting edge has receded. Where the edges of the teeth are parallel or nearly parallel to the axis of the cutter the profile is of course not appreciably affected by grinding back the faces of the teeth. A further means of avoiding such errors is also to be found in grinding the tops of the teeth in the manner subsequently described.

As it is found advantageous, in order to obtain a fine finish, to use helical teeth upon milling cutters, a fitting consisting of a sleeve with spiral slot can be mounted on the same spindle as the milling cutter. A pin on a hinged arm centred above the backing-off cutter spindle is arranged to slide in the slot in this sleeve so that, as the frame carrying the copy and the cutter spindle is moved backwards and forwards along the axis of the cutter being backed off, the helical teeth are maintained in correct relation to the backing-off cutter; while at the same time they are backed off to the correct profile. Theoretically, of course, in such cases the axis of the cutter being operated upon could be inclined to the axis of the backing-off cutter spindle at an angle equal to that of the spiral of the cutter being produced, but in actual practice it is found that this adjustment is very seldom necessary, as the cone angle of the backing-off cutter, and also the amount of material which can be removed from the cutting edge of the cutter being produced, are both, comparatively speaking, small.

This machine has thus been found not only capable of backing off satisfactorily cutters of a shape which could not be backed off along the whole length of their profile in an ordinary relieving lathe in one operation, but it has been found possible to do the backing off in, approximately, one-third of the time required on a relieving lathe, whilst at the same time a less expensive class of labour may be employed, and the finish of the teeth is found to be better.

(4) *Grinding Cutters.*—The machine used for sharpening the cutting edges of the hardened milling cutters and subsequently regrinding their faces or edges as required from time to time has a grinding wheel mounted upon a spindle suspended on a swinging frame and follows the work by the use of a former, the profile of which is of the same magnitude as the one to be ground. In an ordinary way this former would not have the exact outline of the shape desired on the finished cutter, corrections having to be applied for the diameters of the tracing roller and also of the grinding wheel, the latter item being, of course, itself variable. This difficulty is overcome by using grinding wheels of special fast-cutting artificial stone which will perform a considerable amount of useful work before being appreciably reduced in diameter, and by making the diameter of the tracing roller equal to the diameter of the grinding wheel; there is in addition, of course, an adjustment for raising or lowering the former.

The milling cutter being ground is, as before, mounted upon a dividing head in the case of straight cutters, or upon a dividing head provided with helical sleeve in addition in the case of helical teeth cutters, and all the teeth are first ground along the tops to profile and afterwards in the usual manner down their faces, the grinding wheel being, of course, set over to the angle of the spiral. The cutter thus finished has edges both of the maximum keenness and also of the maximum endurance due to correctly hardened high-speed steel, as only the thin skin partially oxidised in heating before hardening is removed.

Hitherto the apparatus employed upon sharpening profile cutters for milling machines in repetition work, such as is produced in small arms factories and elsewhere, has required the handling and attention of men with considerable training and skill, liable to error and consequently well paid to avoid it. The provision of simple machines such as those described now enables an unskilled man to regrind correctly all cutters brought to him with considerable rapidity and the minimum possibility of error. By standardization of the pitches of the teeth and their angles, and by the provision of suitable templates for each of the cutters commonly required, the use of these machines has been found to result in distinct economy, both in the upkeep of cutters and also in the quality of the work turned out.

Considerable advantages result from being able to reform accurately the contour of the teeth in addition to grinding the face. In ordinary use the teeth of milling cutters are damaged not only on the face but to an even greater extent on the top, and it has frequently been found that removing, say, 0·002 inch from the top has as beneficial an effect as removing 0·006 inch from the face, and with this additional advantage, that, when a tooth has been ground to its fullest extent from the face, it can be further sharpened on the top whilst still retaining its correct figure, until the tooth is too short through not allowing the necessary clearance; and this consideration will in many cases lengthen the life of a cutter by 10 per cent.

The life of some milling cutters prepared by the methods indicated above has been extraordinary; for example, a cutter working in a self-acting cross milling machine and operating upon the bodies of the service rifle at an average cutting speed of 69 feet per minute, with a feed of 1¾ inches per minute and a depth of 0·08 inch, and taking a cut of an average width of 1$\frac{1}{16}$ inch and ⅞ inch long, has produced, at

the time of writing, 39,170 bodies and is still good for about half as many more. This particular cutter has been reground across its face twenty-five times. The composition of the steel upon which it operates is 0·5 to 0·6 carbon, with an ultimate tensile strength of not less than 35 tons per square inch.

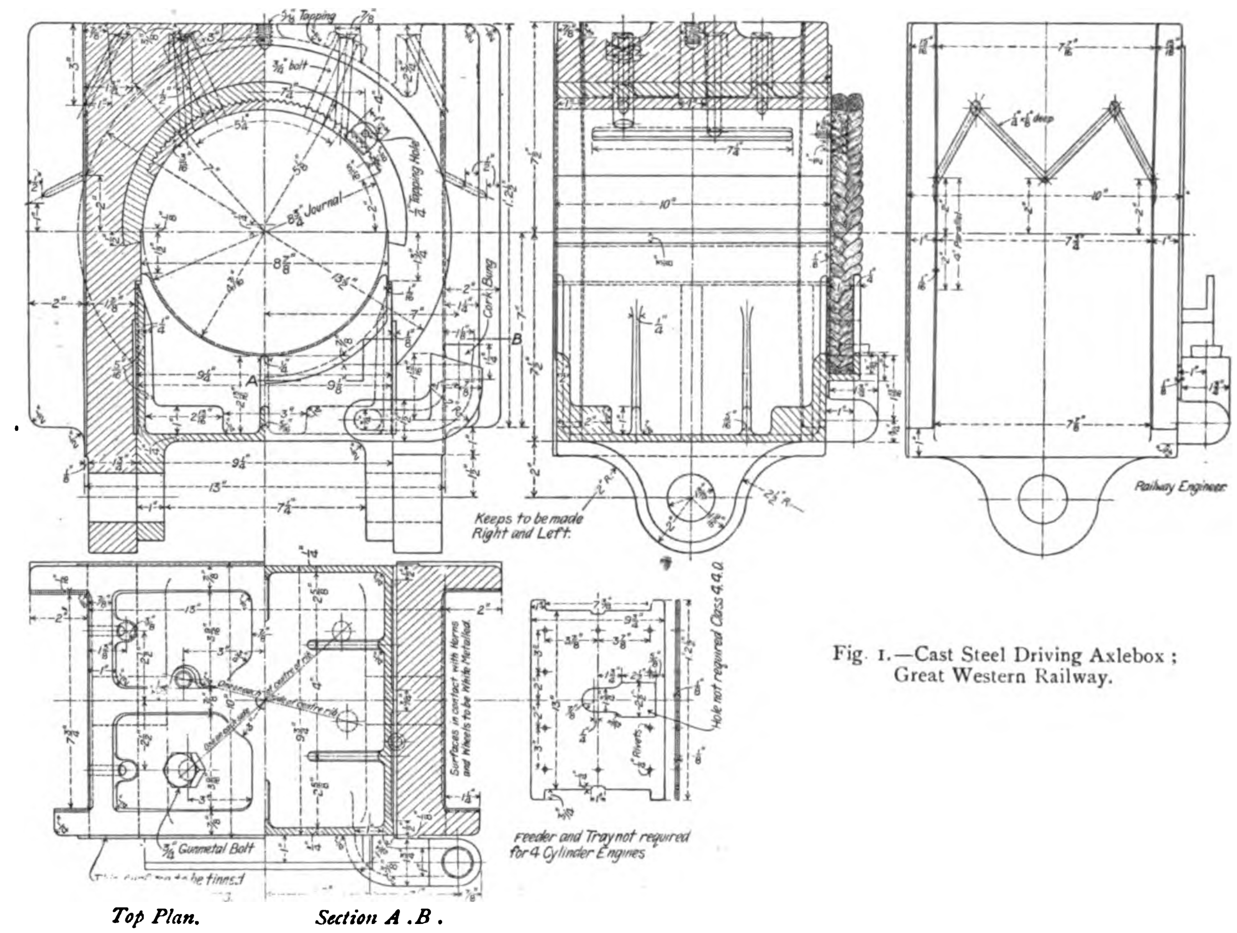


Fig. 1.—Cast Steel Driving Axlebox ; Great Western Railway.

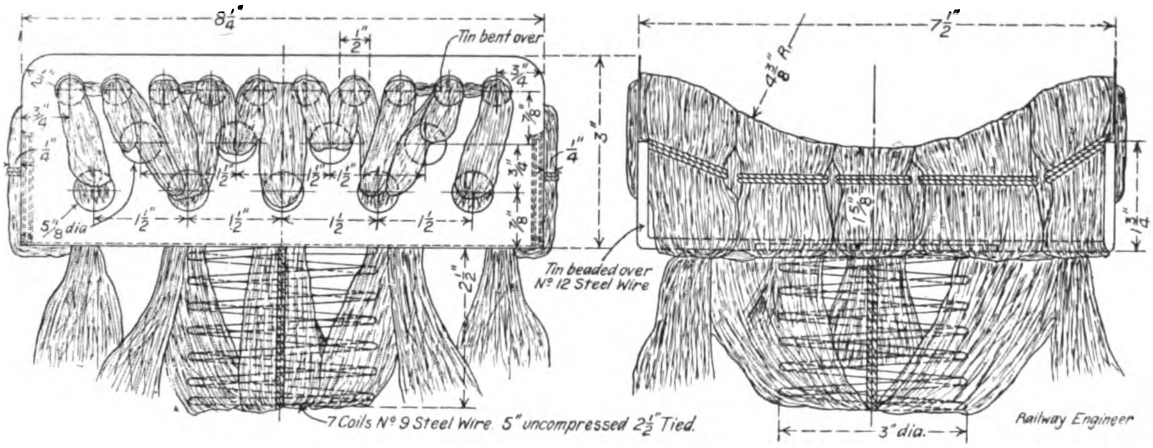


Fig. 2.—Axlebox Pad ; Great Western Railway.

Locomotive Journals and Bearings.—I.

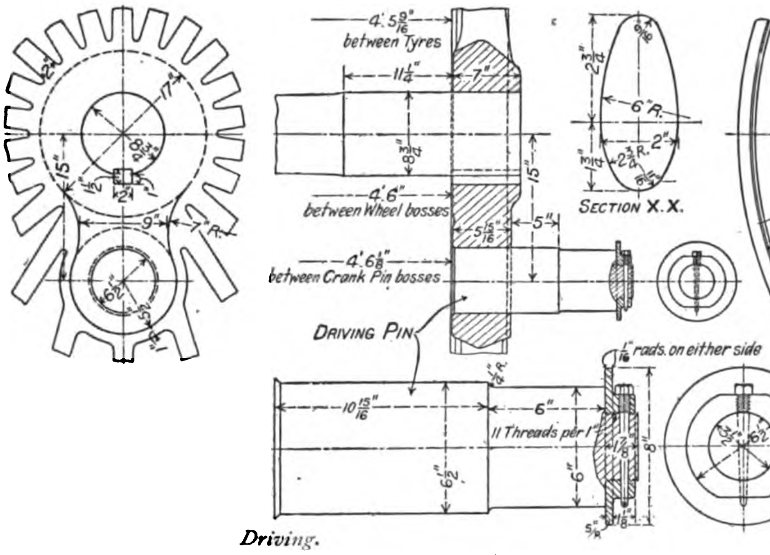
THE successful working of modern express trains making long non-stop runs at high speeds depends—assuming, of course, that the boiler is equal in all respects to the duty demanded of it—mainly, if not entirely, upon the cool and smooth working of the journals in their bearings.

The methods of obtaining—as it most undoubtedly is obtained—this result differs in detail on the engines of nearly every railway in the country, and the object of this and succeeding articles is, by the courtesy of the locomotive engineers concerned, to show various designs and note the points of difference in detail which, though the object in view is approximately the same, experience has proved to be most suitable for the exact work the engines have to perform.

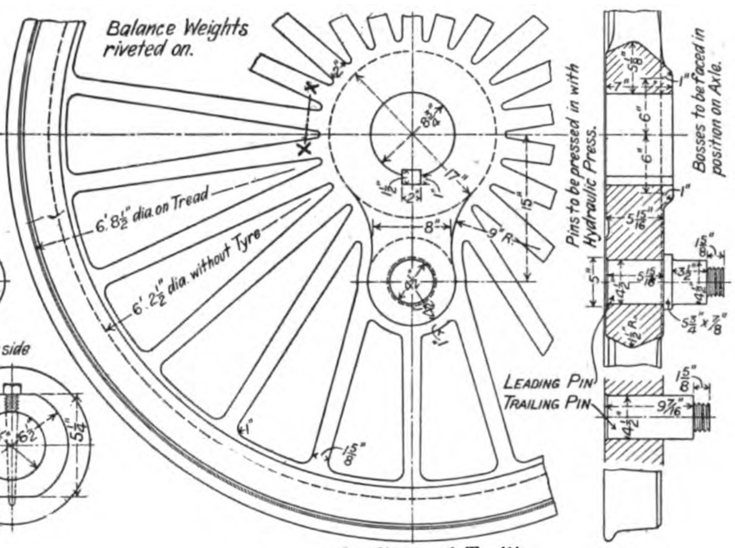
The principal and most trying journals and bearings on a locomotive are those of the Driving Axle, the Connecting Rod and the Coupling Rod. It is those bearings, therefore, that we shall illustrate.

Great Western Railway.

The engines designed for the Great Western R. by Mr. G. J. Churchward, M.Inst.C.E., the chief superintendent of the locomotive, carriage, and wagon department, make the longest regular non-stop journeys in the world. They are of great weight and power, and carry the highest boiler pressure



Driving.



Leading and Trailing.

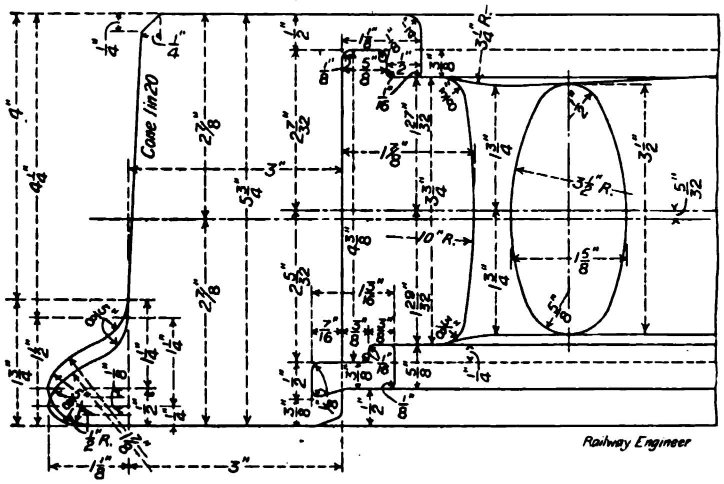


Fig. 3.—Cast Steel Wheels; Great Western Railway.

of any locomotives in the country. Their designs also depart more from "the beaten track" than others do in this country. They work heavy trains over steep gradients and constantly run at speeds of from 60 to 65 miles an hour and upwards for long distances. The details illustrated are used on the 4-4-2 and 4-6-0 classes, which have outside cylinders 18in. by 30in. wheels (new) 6ft. 8½in. diam., and a working pressure of 225 lbs. per sq. inch.

Fig. 1 illustrates a Cast-steel Driving-Axle-box. The size of the journal is 8¾in. diam. by 10in. long. The load is taken on the top of the bearing, there being two oil ways cut 2⅝in. on either side of the centre line. The whole of the crown of the bearing is lined with white metal, which is held in place by a number of V-shaped grooves cut longitudinally in the gun metal bearing, which is secured to the box by two ¾ gun metal bolts. The white metal is carried round on to the face against the wheel.

The top of the box provides four oil cups, from which the horns and journal are lubricated. But the journal is when running mainly lubricated by a pad, which is illustrated by fig. 2. The keep has a oil feeder cast on to it as shown, and which is closed with a cork bung. The free side of the axle-box is protected from grit by a worsted plait secured in place as shown.

Fig. 3 shows the Wheels, the Main Journals, 8¾ by 11¼, and also those of the Crank (6 by 6) and Coupling-rod Pins, 6½ by 5 and 4½ by 3½. The Balance Weights are not cast with the wheel centres, but are riveted on.

Fig. 3 also shows the washer used for securing the coupling rod. This is screwed on, 11 threads to inch, and a taper pin with a screwed head is put through as shown.

Fig. 4 illustrates the steel Connecting Rod, both ends of which, it will be seen, are solid eyes with bronze bushes lined with white metal. The bushes are secured by ¾in. gun metal bolts and are bored out on the inside with a cut of 6 to the inch, and this coarse thread holds the white metal when it is run into it. The white metal is turned round on to the side rubbing surfaces as shown. This method of

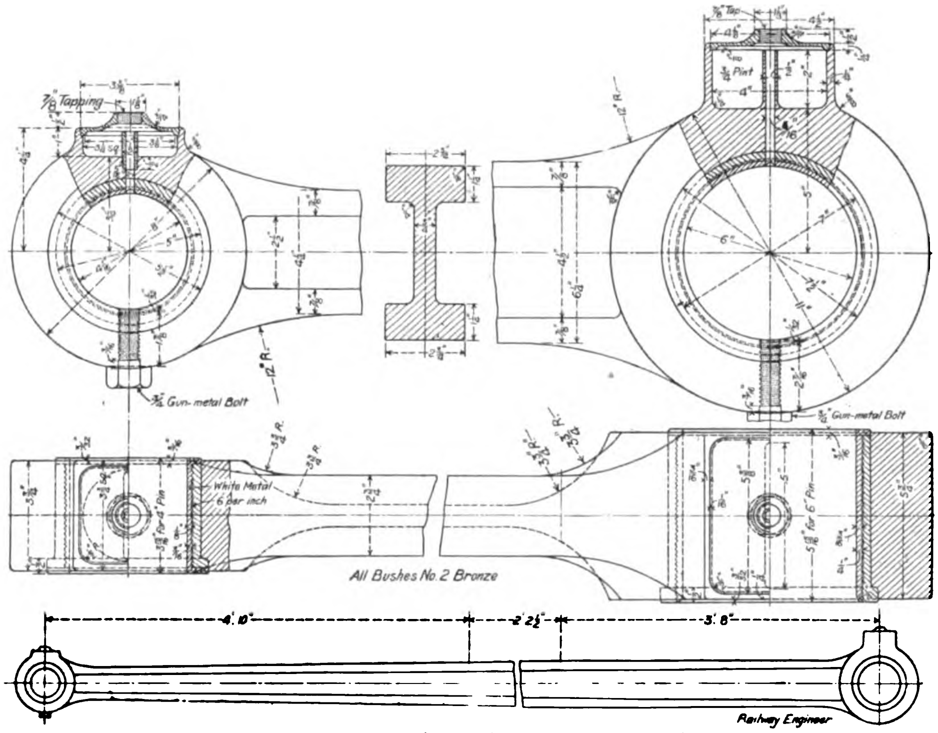


Fig. 4.—Connecting Rod; Great Western Railway.

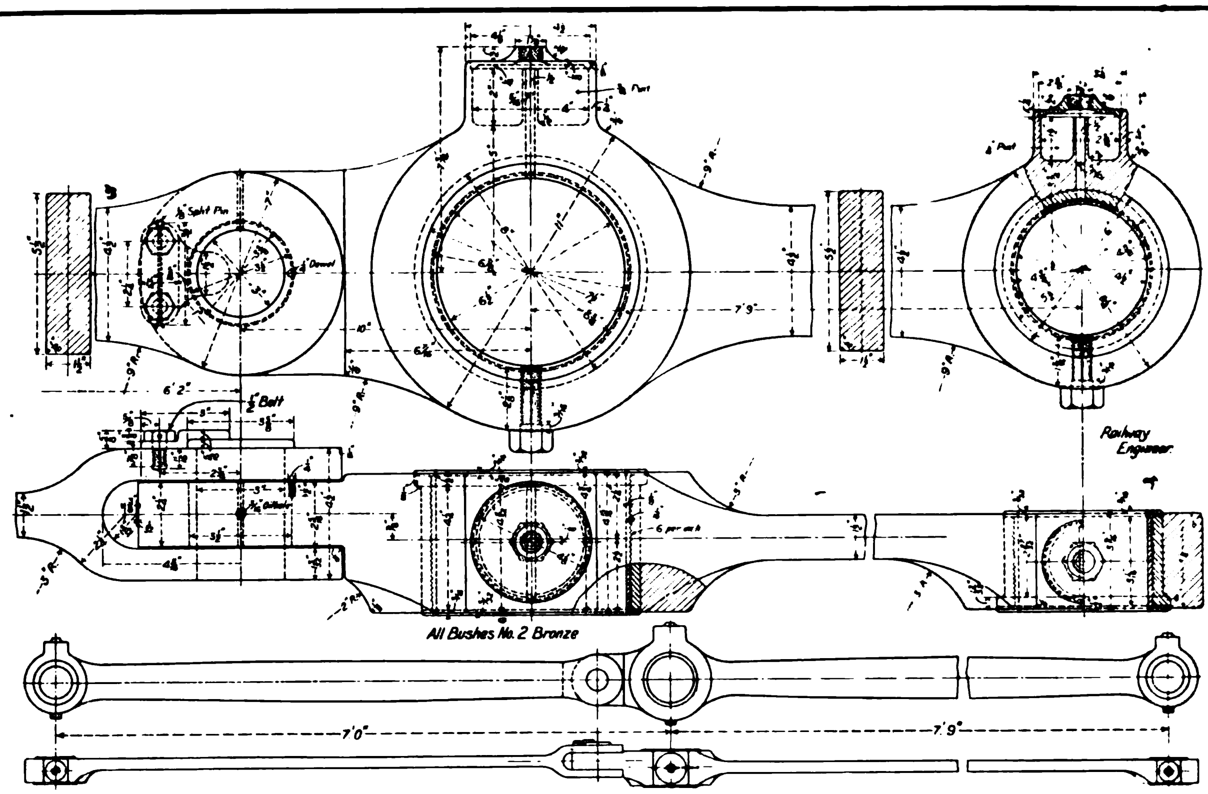


Fig. 5.—Coupling Rod; Great Western Railway.

holding the white metal is, we believe, unique, and has given great satisfaction.

The oil cups are of large capacity, the one at the big end taking ¾ pint. They are cut out of the solid, and are square or rectangular in section. The lids are tightly fitted and the sides lightly riveted over. The centre of the lids have a boss with a ⅞in. tapped hole, and into this a good cork is screwed.

The length of the rod between the centres is 10ft. 8¼in., the big-end bearing 6in. diam. by 5$\frac{15}{16}$in., and the little-end 4$\frac{1}{16}$in. diam. by 3$\frac{15}{16}$in. The rod tapers between the flanges of the I section from 2½in. to 4½in. The thickness of the flanges taper from ⅞in. to 1¼in. at 4ft. 10in. from the small end and are then parallel for 2ft. 2½in., and then taper down to ⅞in. at the big end. The width of the flanges is uniformly 2¾in. The corners are rounded off with a radius of $\frac{1}{16}$in. and the fillets to the web, which is ¾in. thick, have a radius of ½in.

Fig. 5 illustrates the Coupling Rod, which has a solid rectangular section as shown. The bearings are in all ways similar to those of the connecting rod, and are finished in the same way. The bronze bushes are narrower than the rod, and the white metal carried round the faces as shown.

The knuckle joint bearing has a bronze bush, and the pin is held in its place by a clip which is secured to the rod by two ½in. bolts, which in turn are prevented from slacking back by a long ⅛in. split pin passed through both their heads.

The rods are 7ft. and 7ft. 9in. long between the centres. The driving is 6½ by 4$\frac{15}{16}$, and the leading and trailing bearings 4½ by 3$\frac{7}{16}$. The joint pin is 3in. diam. and 2$\frac{5}{16}$in. between the jaws. The rods are 5½in. deep in the middle and 4½in. at the ends, the width being 1½in., the corners being rounded off to a radius of $\frac{1}{16}$in.

These designs may be taken as standard for all outside cylinder engines on the Great Western Railway.

Caledonian Railway.

The engines of the Caledonian R. have to haul very heavy trains over long and trying gradients, and very high speeds are attained. All the engines Mr. J. F. McIntosh, M.Inst.C.E., has designed for the Caledonian R. have inside cylinders, and the details illustrated are of engines with cylinders 19in. diam. by 26in. stroke; 6ft. 6in. driving wheels and carrying a working pressure of 180 lbs. per sq. inch.

Fig. 6 illustrates the built-up crank axle, and shows the main journals to be 9¼ by 8 and the crank pins 9¼ by 4. It will be noticed that the crank pin is ⅜in. larger in diam. than its ends which enter the webs; that the end shafts are reduced ⅛ where they enter the webs, and the middle shaft is reduced to 8½in. diam. The shafts and crank pins are each

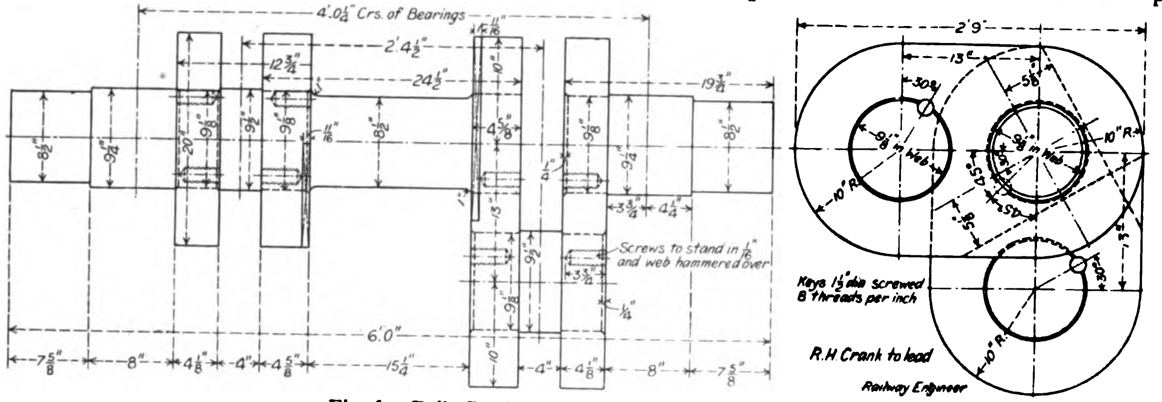


Fig. 6.—Built Crank Axle; Caledonian Railway.

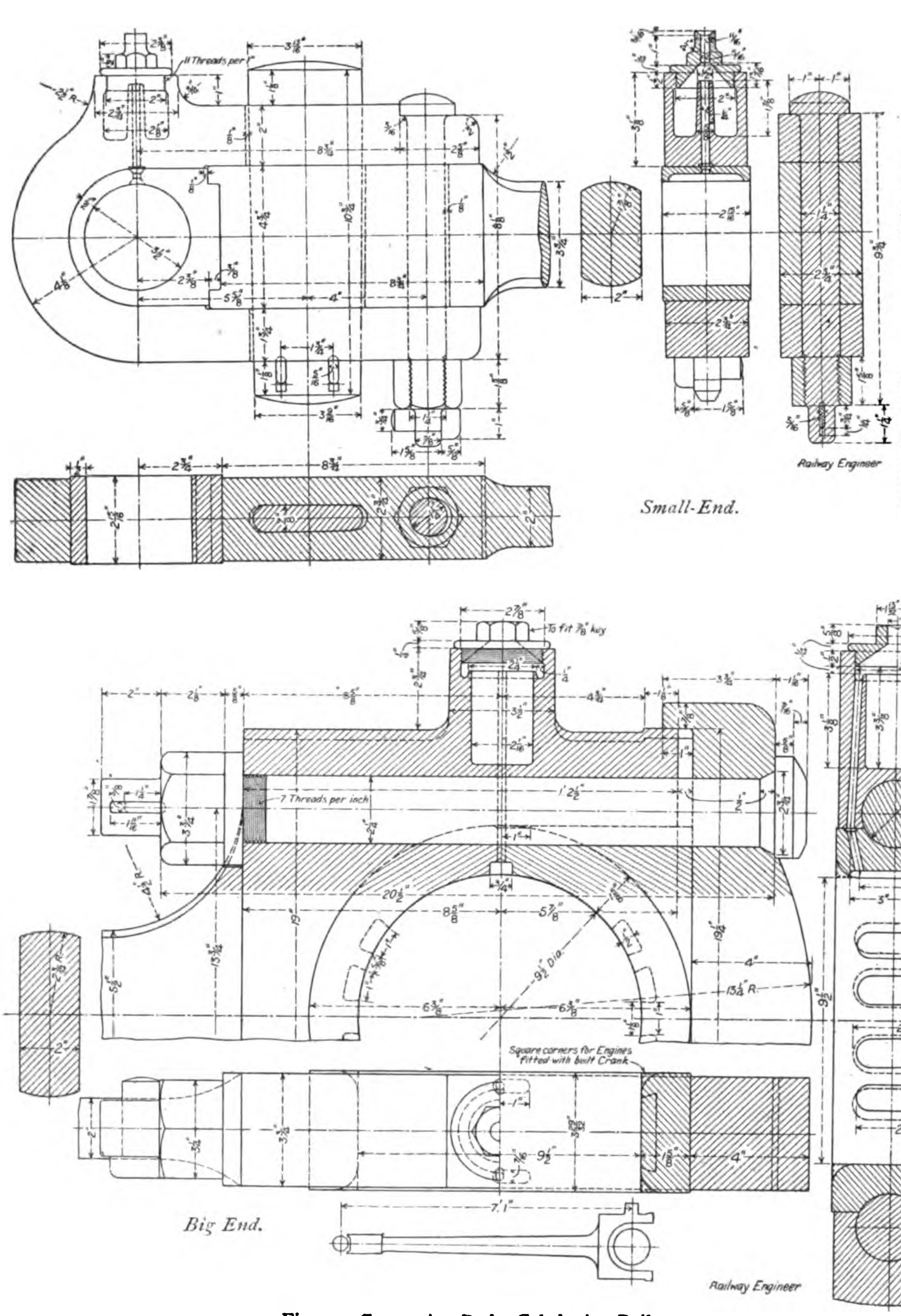


Fig. 7.—Connecting Rod ; Caledonian Railway.

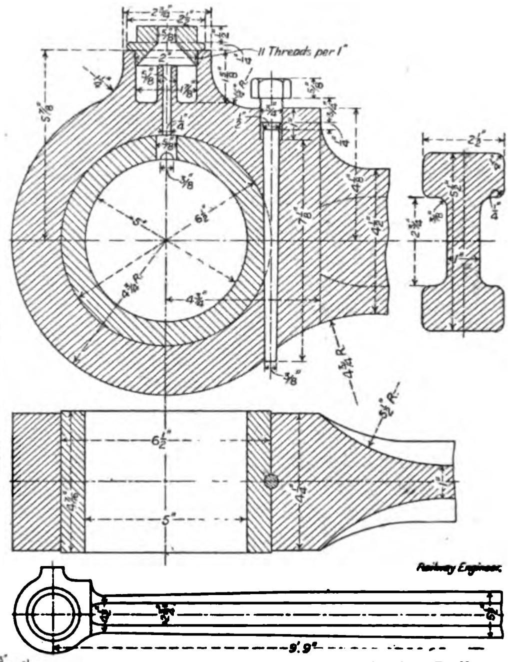


Fig. 8.—Coupling Rod ; Caledonian Railway.

fixed by a 1½ screwed key which is sunk $\frac{1}{16}$ and the web hammered over.

Fig. 7 illustrates the Connecting Rod, which is made of wrought-iron. The big end is of the bolted or marine type. The gun metal bearing is 9½ by 3¾", and is held in position by the two wrought-iron bolts, each 2¼in. diam., and is provided with four white metal fillets back and front as shown. The keep, which is 4in. thick by 3¾in., is provided with lugs which fit over the end of the rod. The bolts have flats cut on their heads to prevent them turning, and their nuts are secured by split keys; they are provided with a conical neck in order to reduce the thickness of the head.

The oil cup is cut out of the solid, and, as shown, has two oil ways, one on either side of the top bolt. It is closed by a brass cap screwed in with a filling hole tapped ⅝ for a wooden plug or cork.

The gun metal bushes of the small-end bearing, 3½ by $2\frac{15}{16}$, are secured to the butt end of the rod by a wrought-iron strap or collar fastened by a taper steel cotter ⅞ by $3\frac{11}{16}$ (middle section) and a 1¼in. wrought-iron bolt. Both the cotter and the nut of the bolt are secured by split keys, and the bolt is prevented from turning by a flat on its head fitting against the recessed part of the strap.

The oil cup is cut out of the solid and fitted with a deep brass screw cap as shown. The rod is 7ft. 1in. between the centres and is rectangular in section with turned top and bottom faces. It tapers from 3¾in. to 5½in. and has a uniform width of 2in.

Fig. 8 illustrates the Coupling Rod, which is 9ft. 9in. long between the centres. The I Section tapers from 4½in. at the ends to 5½in. at the middle, with a wider width over flanges of 2½ in. It will be noticed that all the corners are taken off to a ¼in. radius, and the fillets to the web, which is 1in. thick, are ⅜in. radius.

The gun metal bushes are secured by means of taper pins which are held in their places by ⅜in. set screws as shown. The oil cups are bored out of the solid and closed with brass caps having tapped filling holes as before described. The oil hole through the bush is ⅛in. diam.

The bearings are 5in. by $4\frac{7}{16}$in.

The Accident at Blackfriars Bridge.

Mr. Cuthbert A. Brereton reports to the Board of Trade the result of his enquiry into the causes and circumstances connected with the fatal accident which occurred at the Blackfriars Bridge Widening Works the 28th November last, by which 4 workmen were killed and 2 were injured.

The works, in connection with the widening of the road bridge over the Thames at Blackfriars for the purpose of carrying the L.C.C. Electric Tramways over the River, are being carried out by Sir William Arrol and Co., Glasgow.

The widening consists of an addition of 30ft. on the western or up-stream side, and which necessitated the extension of the foundations of the abutments and of the four river piers. The work was commenced early in 1907.

In order to put in the additional foundations of the piers, steel caissons provided with an air-tight chamber at the bottom and having an access shaft reaching above water with an air lock on the top were employed. The workmen excavate the material of the river bed under water by the aid of compressed air in order to put in the concrete and masonry of the new foundations, and it was while caisson No. 4 (the last one to be put down) was being lowered that the accident happened. The caissons are heart shaped in plan so that the convex end may form the new cutwater of the piers and the concave end fit as nearly as may be the outside of the existing foundations of the present cutwaters of the bridge.

The method of lowering and sinking the caissons has been the same throughout. Timber stagings have been constructed in the river immediately above the bridge opposite each of the piers, upon which the work in connection with lowering and sinking the caissons was carried on. These stagings were supported on piles driven into the river bed, and had an opening or well adjoining the piers through which the caissons are lowered into position. Upon this staging timber trestles were erected on each side of the opening, and upon the top of these trestles four steel girders were placed in pairs side by side across the opening. Across each pair of girders were placed short timber blocks, upon which rested the hydraulic jacks used for lowering the caisson.

The weight of the caisson, together with some concrete which is put in to strengthen it before it is sunk into the ground, was about 240 tons, which was carried on the hydraulic jacks by means of suspending rods or links attached to four brackets near the sides of the caisson, and having slot holes in them through which steel cotters were inserted which carried the weight alternately on the ram of the jack and on the crosshead above the jack during the process of lowering, the actual lowering being effected by allowing the water in the jack to escape by means of a cock or tap attached to the cylinder of the jack. This method of raising or lowering caissons or other heavy weights is one frequently adopted, and as a system is satisfactory and efficient.

It was evident from an inspection of the girders and other appliances used that the immediate cause of the accident was the giving way of the girders placed across the trestles and upon which the jacks carrying the weight of the caisson rested, but as these girders did not appear to have failed by direct vertical pressure it was not at first easy to determine what had been the primary causes which had contributed to their failure, but after a further careful examination of the jacks and other appliances and hearing the evidence given at the enquiry, there is no doubt that the primary cause of the accident was the unequal lowering of the caisson, which caused the whole weight to be thrown upon two only of the four points of support, and this in a diagonal position, the result being that undue weight was brought upon one of the piles supporting the trestles which caused it to sink, thus throwing the trestles and girders out of level, and this, coupled with the fact that the centre of gravity of the caisson was not evenly supported, and also that the lower edge of the caisson was touching the water of the river, which was flowing strongly up stream at the time, all tended to create a transverse strain on the girders which they were not calculated to bear, and consequently caused them to turn over and collapse.

Unfortunately, as frequently happens in cases of this kind, the men who could best give an explanation of what was actually being done at the time have lost their lives, but the evidence given by the contractor's foreman, William Peacock, who was in charge of the work, is that the actual directions to the men at the jacks were given by Peter Irvine, who was killed. It is, however, stated by the men who were working at the pump connected with one of the jacks that shortly after Irvine had instructed them to stop pumping they heard and saw the water exhausting or running out of one of the jacks, while that at which Irvine was stationed was not exhausting, and the man who was at the jack diagonally opposite to Irvine states that he was about to open the cock to exhaust when the accident happened, and these statements are confirmed by the positions in which the handles of the cocks were found after the accident.

The appliances used for lowering the caissons would appear to be of sufficient strength for normal use, but in view of what has happened it would be desirable that in similar operations care should be taken to support the weight as uniformly as possible, and to make all girders and other parts of the temporary structure of sufficient strength to take the greatest load that could possibly come upon them under any combination of circumstances, and further that the girders and other portions of the structure should be of a box form and of sufficient lateral stiffness to withstand sideway strains which they may be subjected to in addition to their normal load.

It is possible, although there is no direct evidence to that effect, that one of the cocks attached to the jacks may have been broken off by a falling cotter or hammer, and it would be advisable that such a vital part of the appliances should be protected from possible injury.

Fires on London Underground Electric Railways.

The following letter has been addressed to the President of the Board of Trade by Major Pringle, inspecting officer, and Mr. A. P. Trotter, electrical adviser:—

We have, in the usual course of our duty, enquired into the circumstances under which an explosion and electric flashing took place in a car on the evening of January 8th at Sloane Square Station on the Met. District Railway. We made a very careful examination of motor car No. 34, which alone was concerned in this case, before any repair work had been carried out, or any of the effects of the explosion and flashing had been removed. Above floor level there was some blistering of the varnish on the wood work surrounding the end left-hand window and doorway, and two panes of glass were blackened with smoke and fumes. No glass was broken, and it was possible by rubbing off the blistering on the wood to see that the red paint work underneath was undamaged. Below floor level the metal pipe carrying the electric lighting wires and a metal junction box were fused. The underside of the timber flooring, immediately above this pipe and junction box, was charred in places. The charring nowhere exceeded a quarter of an inch in depth. No mark of fire could be found inside the car on the flooring, seats or sides. We may here remark that all the woodwork on the Company's cars in proximity to electric conductors has been rendered non-inflammable. This, and other occurrences of a similar kind, have proved that the wood will char under the effect of intense heat from electric flashing, but will not catch fire. The real combustibles in this fire, if we use the word, were copper, iron and brass. Such electric arcs continue until they exhaust or burn themselves out, or until the current is cut off, as was done at Sloane Square. The ordinary method of extinguishing a fire is useless for electric arcs. This particular case was caused in all probability by failure of the insulation of the electric lighting wires owing to damp. The heating of the wires resulted in the liquefaction of a small plug of bitumen. An explosion of bitumen vapour followed, causing smoke and fumes. Subsequently electric flashing took place along the pipe and at the junction box under the car. The conductor in charge of the car states that he immediately entered the door at the corner where the explosion

had taken place and worked the air valve which actuates the double doors in the centre of the car. The doors opened in the usual way; they had not to be forced or held apart. The passengers, 8 in number, stepped out on to the platform through the open doorway, without any apparent panic or alarm. No complaint of injury or danger was made to either the station inspector or any of the Company's officials. Arrangements also exist, on Underground as well as on Tube Railways, to allow passengers in case of need to descend from a train at either end. In our opinion the apprehensions of danger which have been expressed by writers to the newspapers are not justified by the facts. The main danger in any such cases of fire will be from panic. For this reason we deprecate the writing for publication of alarmist letters

Distribution of Current to Trains on Electric Railways.—IV.*

Distribution by Single Phase Alternating Current.

THE conditions for distribution by single phase alternating current are similar to those with two wire continuous current, up to a certain point. Two conductors are necessary, as with two wire continuous currents, one to carry the current to the train, and the other to bring it back to the generating station. There is one very grave difference, however, that meets us at the outset. The track rails cannot be employed for the return, and a separate return cannot be employed, unless it is securely bonded to the track rails. Further, the use of single phase currents is associated with the use of very much higher pressures than have been hitherto employed with continuous currents. It was mentioned in a previous article that the continuous current motor had been practically confined to pressures in the neighbourhood of 500 volts, the reason of this being the grave difficulties which arise with the insulation of the commutator, with higher pressures. It was also mentioned that M. Thury is working at the problem of continuous current generators and motors for higher pressures, but so far in this country nothing much above 500 volts has been adopted. It was explained in some previous articles in the *Railway Engineer* that the commutator of the continuous current motor consists of a cylinder of copper, divided up into segments, insulated from each other, the number of segments corresponding with the number of coils on the armature of the motor, and the whole winding of the motor being divided up as much as possible, in order to reduce the sparking at the brush, when each pair of segments passes under it. As the pressure with which a motor is to work increases, so do the number of wires on the armature, and also the number of segments of the commutator, and it will easily be understood that the insulation becomes more and more difficult. On the other hand, with alternating current motors, pure and simple, there is no commutator, and therefore the difficulty of the insulation of the commutator with high pressures is eliminated. Hence it is practicable to employ motors with pressures of 3,000 volts delivered to them. This pressure is employed very largely in mines in this country, and on the Continent, and also on the Continent in factories and other places, and no difficulty is found, so far as the insulation is concerned, nor have any difficulties arisen more than we have with lower pressures, with regard to shock. It may perhaps be mentioned, *en passant*, that the single phase motor pure and simple is not at all suitable for driving locomotives. It will not start by itself, unless a special arrangement is provided for it, and even then it will not start against a load greater than its own full load, while the motor driving a locomotive must start against a load several times its normal. But there are several methods of employing single phase currents, and converting them upon the locomotive.

In single phase alternating currents, and in fact in alternating currents of any kind, though the problem of distribution is similar in many respects to that of continuous current distribution, there are several very important new factors that have to be taken into account. The alternating current, it will be remembered, differs entirely from the continuous current, though it is made to do the same work, as in the case of lighting, and in the case of two and three phase motors. Where the continuous current is moving constantly in one direction, supposing for the moment that an electric current is something similar to a current of water, and moves from a point at higher pressure, to one at lower pressure, the alternating current is constantly rising and falling and reversing its direction. With a continuous current, one of the terminals of the generator is always at higher pressure than the other, and this applies also to the terminals of the motor. It applies also to the conductors connecting the generators with the motors. Certain portions of the conductors are always at higher pressures than certain other portions. With alternating currents this is all changed. In the generator each terminal is alternately positive and negative, from 25 times a second, upwards. The same thing applies to the motor, each terminal is alternately positive and negative, and to the conductors. Alternating currents are continually changing their direction and changing the value of both the pressures and the currents themselves. When we talk of a continuous current pressure of 500 volts, say, we mean that that pressure exists between the terminals of the generator, or the terminals of the motor, or points on the switchboard, as the case may be. With alternating currents, with a pressure of 500 volts, we mean that the pressure rises from 0 to 720, falls to 0 again, rises to 720 in the opposite direction, falls to 0 again, rises again in the first direction to 720, and so on, this taking place from 25 times per second, upwards. In the early days of alternating currents, the periodicity of the currents was as high as 166 per second, but the tendency has been to gradually reduce the number, especially for power work, as a high periodicity means considerable waste, and at the present time 25 per second, or 1,500 per minute, is that employed for power work, and 50 per second or 3,000 per minute for lighting work. A lower periodicity would be employed for power work with advantage if engineers could be sure that the current would not be used for lighting, but the sensitive filaments of incandescent lamps show the variation in the pressure at anything below 25 per second, and sometimes even at that figure. The same remarks apply to the current, it is constantly changing in value from instant to instant, in exactly the same manner as described for the pressure, and in alternating current work it may be taken that currents are constantly surging to and fro, through the generators, through the conductors connecting them to the motors, and through the motors.

Alternating currents are employed, as explained above, for lighting and poewr, very much as continuous currents

*No. I. of this series appeared in the *Railway Engineer*, August, 1907; No. II. in October, 1907; No. III. in December, 1907.

are, with the differences mentioned, and the power delivered by alternating currents is calculated just as the power delivered by continuous currents is, but with certain modifications. The power delivered by an alternating current is found by multiplying together the working pressure and the working current, and another factor to be mentioned presently, just as with continuous currents, but the working pressure and the working current are what are known as the effective or virtual pressures, and the effective or virtual currents. The effective or virtual pressures and currents are really the average of the whole of the pressures and currents throughout the cycle, but the average is found in a special manner. The effective pressure of any alternating current is found by taking the sq. root of the mean of the squares of all the values through which the pressure passes, and the effective current is found in a similar manner, by taking the sq. root of the mean of the squares of all the values through which the current has passed. This rule is known as the root of the mean sq. value, and it has been made great fun of in after dinner speeches. The reason for its use is, the effective work done by an alternating current is measured by that which would be done by a similar continuous current. Thus, incandescent electric lamps are made to work at various voltages, as, say, 100 volts, 200 volts, and so on, and it makes no difference to their working, whether the supply service is worked by continuous currents or alternating currents. The incandescent electric lamp, it will be remembered, gives out light because the electric current passing through it generates heat, and because its temperature, when the current passing is sufficiently strong, is raised sufficiently high to give out light. The heat delivered then to the filament of the incandescent lamp is the measure of the work that either the continuous current or the alternating current will perform, when delivered to the lamp, and it varies directly as the square of the pressure or the square of the current; and, therefore, the alternating current whose average pressure is such that it will deliver the same quantity of heat to an incandescent lamp filament, as a continuous current of, say, 100 volts pressure or 1 ampere current strength, has an effective pressure of 100 volts, or an effective current of 1 ampere, and this means that the square root of the mean of the squares of all the values through which the pressure and current has passed is the same as the figure given for continuous currents, and that is the effective pressure or effective current. And this applies to any pressure and any current, though it is arrived at theoretically by the rule given above, that looks so much like a play upon words. For practical purposes it will perhaps be sufficient to note that the effective pressure is 0.707 of the maximum pressure, and conversely, the maximum pressure is 1·414 times the effective pressure. These figures apply also to the currents, the effective current is 0·707 times the maximum current, and the maximum current is 1·414 times the effective current strength. It should be noted *en passant,* in connection with the matter of pressure, that the alternating current is more dangerous in the matter of shock, because the real shocking pressure is 2·828 times the working or effective pressure. When a man takes hold of a piece of apparatus, and places himself in such a position that he is exposed to an effective alternating pressure of, say, 200 volts, he is really exposed to a shocking pressure equal to 560 volts continuous current, and this is the reason why so many fatal accidents have occurred with 200 volts alternating current.

Alternating Currents and Induction.

There is another point in connection with alternating currents that had better be dealt with, *viz.*, induction. Whenever an electrical pressure is applied to the ends of a conductor, though apparently the current which follows passes immediately upon the application of the pressure, in reality it is not so. Before the current can pass from one end of the conductor to the other it has to satisfy two requirements, practically two charges, which are known respectively as electrostatic and electro magnetic induction. At the present moment electrostatic induction need not detain us long. It is of importance in the case of long insulated cables, which are delivering alternating currents, and it is the charge of electricity which the insulating envelope of the cable takes up, whenever an electric current passes through the conductor it surrounds. The conductor of an insulated cable, its insulating envelope, and any conductors with which the insulating envelope are in contact outside, such as its armour, or the lead covering of certain cables, together form what is called an electrical condenser. The electrical condenser has the property of absorbing a certain quantity of static electricity, by what is known as electrostatic induction, and when an electrical pressure is applied to the ends of an electrical conductor, every inch or foot of the condenser formed by the cable has to be charged electrostatically before the current can pass on. Overhead conductors, insulated by being carried on porcelain insulators, and third rail conductors carried on the track, also form condensers with other conductors in the neighbourhood, the air, etc., forming the insulator, but the electrostatic induction in this case is very small. In the case of long insulated cables it is of importance. It is the other form of induction, however, electro magnetic induction, that is of so much importance in connection with the distribution of electric currents for train work. In addition to charging the condenser formed by the cable, when a current passes through a conductor it creates a magnetic field around the conductor, and the current can only reach the end of the conductor when it has created a field throughout its whole length. When the current ceases in the conductor the energy that was delivered to the condenser, and to the magnetic field, are returned to the conductor, and in the case of the energy delivered by the magnetic field, this is the principal cause of the sparking which takes place, at switches, etc., when the current is broken. The returned energy from the magnetic field takes the form of an increased pressure, which resists the opening of the circuit, and causes the current to attempt to persist. In the case of alternating currents, the pressure and current, as explained, are constantly rising and falling, and reversing, and consequently there is a constant charge and discharge of the condenser formed by any cables in the service, and there is a constant change in the magnetic field surrounding the conductors. The magnetic field is created, following the rise of the current, gradually reaching its maximum value, and as the value of the current recedes from the maximum, the energy delivered to the magnetic field commences to return to the conductor, and again, when the current commences to rise in the opposite direction, energy is again delivered to the magnetic field surrounding the conductor, but in the opposite sense to that during the first half of the cycle, it again gradually increasing to the maximum, and

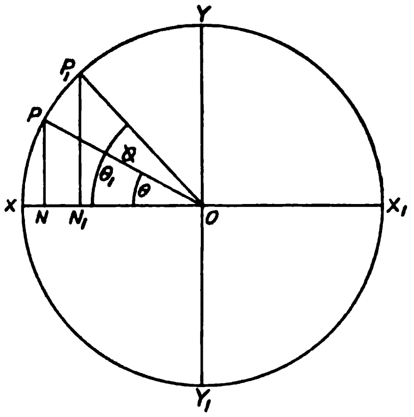
again gradually returning to the conductor, as the value of the current decreases. These phenomena lead to the peculiar features of all alternating current work, particularly where power transmission is concerned, in which what is known as the power factor appears, as an additional factor in the equations dealing with the power delivered by the current. Where the conductor is coiled on itself a number of times, as in the construction of dynamo machines, generators and motors, the current passing in each turn of the coil acts independently of the current in all the other turns. That is to say, as the current circulates through every turn in the coil, and in each turn induces the effects described above, these effects are enormously multiplied where there are a number of coils, as in all dynamo machines. And this leads to the peculiar phenomena that the current lags behind the pressure which creates it. From what has been stated above it will be understood that the creation of the magnetic field, and the other phenomena that have been described, tend to delay the passage of the current through the conductors, after the necessary pressure has been delivered to them. Hence the formulæ which rule for obtaining the power present in any electric circuit do not apply in the case of alternating current circuits, except where there are no inductive apparatus, as they are termed, where there are no coils through which the current has to pass, and no condensers to be charged. It should be mentioned that the electrostatic induction created by the condenser is opposite to the electro magnetic induction created by the magnetic field, and that if the two can be equally balanced, the power factor becomes unity, as will be explained, and the formulæ for the power delivered to any electric circuit becomes the same as with continuous currents. For railway work it is very rarely that the electrostatic induction is more than a small fraction of the electro magnetic induction, but on the other hand it is possible to artificially produce the same effects as those produced by electrostatic induction, and so to balance the electro magnetic induction. This is dealt with further on. The fact that the current created by a given pressure, in a given conductor or system of conductors, only flows through the conductors a certain time after the pressure has been applied, leads to the fact that the product of the current and pressure at any instant do not measure the power in the circuit at that instant. At the commencement of the cycle, for instance, when the pressure is applied, the current is non-existent, and the current does not commence to flow until the pressure has acquired an appreciable value, depending upon the conditions of the circuit. As the pressure increases, the current also increases, but is always less than the apparent pressure would rule, and when the pressure commences to decrease, after passing its maximum, the current still continues to increase, up to the maximum, and then commences to decrease, and so on. It is usual to describe the difference in time between the pressure and current as the angle of lag of the current. This is taken from the method that is adopted for describing the variation of pressure and current in an alternating current circuit, by what is known as a clock diagram. In the clock diagram the radius of a circle is supposed to revolve round the centre of the circle, sweeping out angles from 0 to 90, to 180, 270 and 360, these angles representing, in time, the period of a complete cycle of an alternating current. When the current lags behind the pressure, one radius will represent the pressure, and a second one the current, as shown in fig. 16, and the angle between the two radii is known as the angle of lag, and the formulæ that have been given in previous articles for the power delivered to a continuous current circuit become the formulæ for alternating current circuits, with the addition of the cosine of this angle of lag. It is usual to call the angle of lag by the Greek letter ϕ, and the formulæ becomes :—

$$W = E \times C \times \cos.\ \phi : W = C^2 \times R \times \cos.\ \phi; \text{ and}$$
$$W = E^2 \times \cos.\ \phi \div R.$$

Where, as before, W is the work done, E is the pressure in volts, R is the resistance in ohms, and C is the current in amperes.

The rate of doing work in H.P. is given by the formulæ :

$$H.P. = E \times C \times \cos.\ \phi \div 746. \quad H.P. = C^2 \times R \times \cos.\ \phi \div 746.$$
$$H.P. = (E^2 \times \cos.\ \phi) \div (R \times 746).$$



OP_1 is the radius representing pressure, OP that representing current. Pressure varies as sine θ_1, currents as sine θ.

The power factor, as will be understood, decreases with the increase of induction. In a circuit devoted entirely to electric light, where there is very little induction, cos. ϕ will equal 1. It will be remembered that cos. O = 1 and cos. 90° = O, the latter representing the paradoxical case, where current and pressure are being generated, but there is no power available in the circuit. The value of the cosine decreases, as may be seen from any table of cosines, as the angle increases, and the angle of lag increases as the electro-magnetic induction increases, and again as the coils into which the conductor is formed increase, and with other matters. In particular, alternating current motors and alternating current transformers, working with light loads, have very low power factors. A power factor of 0·5, and even less, is not at all uncommon, with an ordinary single phase motor, or a single phase transformer, at light load. And this is one of the reasons for not employing the ordinary single phase motor for railway and other kinds of work. In order that the motor should have power to start against a heavy load, and to give the required accelleration, it would have to be constructed very much above its normal power, and would consequently be working at very light load, for a large portion of its time, and would be exceedingly inefficient.

(To be continued.)

Official Reports on Recent Accidents.

At **Ebbw Junction, G.W.R.,** *on 20th September. Major J. W. Pringle reports that :—*

The 7.40 p.m. up express passenger train collided head-on with a special down goods train, from Rogerstone to Cardiff. Both engines were derailed and badly smashed. The leading coach (fortunately empty) and the next were destroyed. Three other carriages were derailed. Six goods wagons were broken up and four more derailed and badly damaged. The driver of the goods train was killed and the fireman very seriously injured; 12 passengers were injured, and the driver and fireman of the passenger train were badly bruised and shaken.

The passenger train consisted of a 4-coupled bogie engine (No. 3728), tender and 6 coaching vehicles, fitted with a steam brake on the coupled engine wheels, controlling the vacuum automatic brake, on the six tender wheels, and on 44 out of 46 of the coach wheels. The total weight of the train (unloaded) was 197 tons 4 cwt.

The goods train consisted of a 6-coupled tank engine (No. 3161) with a pony axle in front and radial axle in rear, and one empty and 47 loaded four-wheeled wagons, with two four-wheeled brake vans. The rear brake van (No. 17,523), weighing 13 tons 2 cwt., was alone in use. Eighty per cent. of the load (56 tons 4 cwt.) carried by the coupled wheels of the engine was braked by steam power. The engine was running chimney first. The total weight of engine and train was 815 tons 7 cwt. 3 qrs.

At Ebbw Junction, on the main line between Cardiff and Newport, about 1¼ miles from High Street (Newport) Station, a double loop from Park Junction connects the Western Valleys Branch with the main line towards Cardiff. The western pair of lines are the up and down main, and the eastern pair the up and down relief. The loop, or Western Curve, forms a double junction with the up and down main lines, and curves sharply towards the west.

Ebbw Junction signal-box is on the west side of the main road, and the Park Junction down (to Cardiff) starting signal is 761 yds. and Park Junction signal-box 1,270 yds. to the north-west.

The main lines are practically straight and level. The down loop line on which the goods train travelled curves sharply to the right, with a radius of 16 chains, towards Ebbw Junction, and the gradients fall from

Park Junction down starting signal at 1 in 62 for 113 yds.; at 1 in 70 for 198 yds.; at 1 in 129 for 176 yds., and level for 110 yds. (collision).

Up to October, 1904, regulations were in force for down mineral and goods trains on the Western Curve to be stopped at Park Junction, and for the guard, when the train comprised more than 20 wagons, to pin down as many wagon brakes as the enginemen considered necessary, so that the train should be thoroughly under control. The latest regulations, issued October, 1904, cancelled the former as regards the application of wagon brakes. In lieu thereof no trains were allowed to be despatched from Park Junction down starting signal except under full block protection.

A mistake on the part of Lodge, signalman at Park Junction, was the immediate cause of this collision. He offered the special goods train to Ebbw Junction at 7.41 p.m., but it was not accepted. At 7.47 p.m. he allowed the train to draw slowly past his signal-box on to the down line of the Western Curve as far as the starting signal, where it stopped. This signal is worked from Park Junction signal-box by lever No. 6.

At 7.56 p.m. a mineral train for Newport arrived at Park Junction, and was offered by signalman Lodge to Gaer Junction (Newport), but it also was refused. He immediately decided to run this mineral train into a refuge loop in order to clear the main line to Newport for a passenger train, and therefore proceeded to set the necessary points and bars. The signal controlling the entrance to this refuge loop is worked by lever No. 7. Lodge made the mistake of catching hold of No. 6 instead of No. 7 lever, and drew it over, thereby unintentionally lowering the down starting signal for Ebbw Junction to the "clear" position. He frankly acknowledged that, after the collision, he examined his lever frame and found that No. 6 was pulled over instead of No. 7.

Trains from the Western Valleys Line are never stopped at the Ebbw Junction down home signal unless both guard and enginemen are aware that the train will be so stopped in order to pick up loads at the Junction. Only short trains with small loads are so stopped, and in such cases also the trains are only accepted under full block protection, with the Junction points set for the crossing.

The special goods train had a full load of 50 vehicles behind the engine, and was booked to run through to Cardiff. When, therefore (as above described), the Park Junction down starting signal was lowered the driver (Workman) of this train was fully justified in expecting a clear run over the Junction crossing in accordance with the instructions. He whistled for his guard, who was on his way back to Park Junction signal-box, to return to the train, and, on receipt of a white light from the guard (Vaughan) started his train down the bank. The Ebbw Junction home signal was found to be at danger, but driver Workman could not have seen its danger position until he was passing the railway overbridge, distant about 230 yards from the home signal. He appears then to have done his best to stop his train by using the engine brake, and by whistling for the guard's assistance, as soon as he found the Junction home signal against him. But the weight of the heavy train on the steep gradient was too much for him, and his engine ran by the home signal on to the crossing of the up main line. The engine of the goods train weighed 79 tons 14 cwt., of which 45 tons was braked, and the weight behind the engine was 735 tons 13 cwt., of which 13 tons 2 cwt. (one brake-van) only were braked. The speed of the train was not in excess of the prescribed limit of 15 miles an hour.

All the up main line signals had been "cleared" for the express passenger train, which at this moment was approaching Ebbw Junction signal-box at a speed of 45 miles an hour. Despite the efforts of yard inspector Ballinger to warn the express, and of signalman Lippiatt, at Ebbw Junction, to stop the express by placing his signals at danger, driver Kennett had not time to do more than apply his brakes before the collision took place. The express engine struck the right-hand leading end of the goods engine, and turned it end for end, so that it eventually fell over on its right side.

It appears that a relief brakesman had been sitting in the Park Junction signal-box for a quarter of an hour before the collision occurred, waiting for a train. Lodge states that he was not engaged in conversation with this brakesman, and that his attention was not in any way distracted by his presence. Lodge suggests that a possible explanation of his mistake may be that he intended, in accordance with his usual custom, to place collars on Nos. 5 and 6 levers in order to remind himself of the position of the goods train standing at the down starting signal. If he had placed these collars he could not have lowered the starting signal without removing the collar. Either, therefore, he must have placed collars on Nos. 4 and 5, instead of on Nos. 5 and 6, or only have placed one collar on No. 5.

On the other hand it is given in evidence by guard Vaughan that after the collision Lodge voluntarily made the statement that he was talking to the brakesman at the time. It is one of the duties of a signalman to observe whether a lever movement is properly responded to by the signal concerned. Repeating indicators are provided for such signals as are not in view from a signal-box. If Lodge had watched the signal worked by No. 7 lever he would presumably have noticed that the back light was not obscured, and that the signal had not answered the lever movement he had made. His attention would then probably have been drawn to the lever and he would have immediately discovered his mistake, and might at once have thrown back the lever and placed the starting signal to danger. Lodge states that he did not watch No. 7 signal because he had no time to do so. The necessity for using the telephone prevented him from noticing the movement of the goods train and taking action to remedy the mistake he had made. In short, his excuse for the grave mistake he made is that the work in the signal-box is too heavy for one man to be able to perform it properly without assistance.

Park Junction signal-box contains 105 levers; of these, 78 only are in use. There are in addition 6 bell instruments, 4 sets of block instruments, and 4 telephones. It is an 8-hour box, and is classed as "special" for the purpose of calculation of wages. The total number of trains dealt with in 24 hours is 278, the maximum number in one hour being 16. In 1899, when extensive alterations were in hand at Park Junction, the assistance of a train-booker was asked for by the signalmen. This was given, as a temporary measure. When the new arrangements were in working order the services of a train-booker were dispensed with. The signalmen protested, and a survey of the general work, lever movements, etc., performed in the signal-box was made, with the result that the men were informed that a case for the permanent appointment of a train-booker had not been made out. In 1907 the signalmen petitioned that, on account of the extra telephone work, the box should be classed as "extra special," and the highest scale of wages paid accordingly. On this recent occasion the signalmen made no reference to the necessity for providing them with services of a train-booker. Again a survey of all the work performed was made. But it was still found to be less than that required by the Co.'s fixed scale for qualification for the "extra special" class. The petition for higher wages was accordingly refused.

The signalling of trains, which includes watching of the movement of the semaphores and signal lights, and of the trains themselves, is of far greater importance than the despatch of telephone messages. Lodge suggests that it was the necessity for using the telephone which prevented him in this instance from observing his out-door signals. But when further questioned Lodge explained that he had not been called up on the telephone, but was of his own accord asking for information regarding the position of certain passenger trains. In the circumstances, whilst it may be freely acknowledged that Lodge made the mistake from pure inadvertence, the excuse he offers for the mistake, that his work was so continuous that he had not the time to carry it out in a proper manner, cannot be accepted. He came on duty at 2 p.m., after 16 hours' rest, and had been at work about 6 hours.

In order to prevent the recurrence of a similar mistake, the Park Junction down starting signal for Ebbw Junction should be controlled either electrically or mechanically from Ebbw Junction signal-box. It will then be impossible for the signal to be lowered without the consent and action of the signalmen in both these Junction boxes. The Company is prepared to arrange for the addition of this.

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At **Wath, H. and B.R.** *On September 25th. Lieut.-Col. P. G. von Donop, R.E. (in conjunction with Mr. Thos. Carlton, of the Marine Department of the Board of Trade) reports that*:—

An explosion occurred in the fire-box of a 6-coupled tank-engine which was about to take a train from Wath to Wrangbrook. The driver, who was on the footplate, was blown off the engine, and he died in a few hours.

The engine was in charge of driver Brook and fireman Heffer. These men had come on duty at Cudworth at 2.50 p.m. on the afternoon of the 24th September, and had been employed during that day in running short trips between Wath, Hickleton Station, and Wrangbrook Junction. They had finally arrived at Wath at 1.20 a.m. on the 25th, with a loaded train. On arrival there they put that train away and got ready a new one, consisting of 20 wagons and a brake van, which was due to go to Wrangbrook. The engine would have been run home "light" to Cudworth. The train was ready by 2.50 a.m., and the guard then instructed the driver to get water; he did so, and the engine was then backed on to the train, which was standing in one of the sidings, marshalled ready to go away; the engine was not, however, coupled up to the train. When the engine had got back on to the train the driver told the fireman to go to the signal-box for the staff. Heffer did so, and he had just left the signal-box to return to the engine when the explosion occurred. The weather at the time was very foggy, and the guard states that the shunting operations had been slightly hindered thereby.

The engine was found after the explosion to be derailed a short distance to the left of the line of rails on which it had been standing, and it was leaning over slightly to the left. The whole of the left-hand side of the copper firebox was blown completely out of the engine, and it was found lying on the ground about 40 yards to the left of where the engine was standing.

Mr. Carlton reports that:—The boiler is of the ordinary locomotive type, with a steel shell and copper fire-box. The mean diam. of barrel 4ft. $1\frac{1}{8}$ins., length 10ft., and plates $\frac{7}{16}$in. thick. The fire-box is 4ft. $9\frac{3}{4}$ins. long, 3ft. $4\frac{1}{2}$ins. wide, 5ft. 4ins. high at the back end and 5ft. 9ins. at the front, all inside dimensions. The top and side plate $\frac{1}{2}$in., the tube plate $1\frac{3}{8}$in., and $\frac{1}{2}$in.; the back plate $\frac{5}{8}$in. The water spaces at the sides and ends 3in.; the stays $1\frac{1}{8}$in. diam., and approximately barely 4in. pitch. The crown plate was supported by 12 transverse rows of stays, 9 of which were attached to the shell plate, the 3 forward rows being screwed into girders, the ends of which were supported on short angle-bars riveted to the outer shell plate. There were two openings in the shell, each $2\frac{1}{2}$in. diam., for the duplex safety valve, which was of the usual Ramsbottom type, loaded to a pressure of 150 lbs. per square inch. The other usual mountings are fitted to the boiler.

The explosion was a violent one, the left-hand side of the fire-box being entirely torn out and blown about 40 yards away. The re-acting pressure of the steam in escaping from the fire-box lifted the rear part of the engine until the forward part of the engine frame came in contact with one of the rails, and while in or near this position the

fractured side of the fire-box finally separated from the boiler. The rails were broken and twisted and the engine appears to have fallen again almost in its original position, but slightly to the left-hand side.

The explosion was caused by the failure of a group of stays, about 30 in number, situated near the bottom of the left-hand side of the fire-box in the 2nd, 3rd, 4th, and 5th rows, counting from the bottom, the attachment of which to the copper plate had become most defective. The clenched heads of these stays were completely wasted away, and this part of the fire-box side was in consequence dependent for support on the screwed parts of the stays in the stay holes, but owing to the repeated hammering and caulking of the ends to make them steam tight the threads had been seriously damaged and the stays had become too short, the ends being below the fire surface of the plate. In this condition they were unable to support the plate, and the latter was forced over the ends in the form of a bulge. Once the bulge started the surrounding part of the plate appears to have slipped easily and rapidly over the adjacent stays, many of which also were without proper heads, the scalding steam and water escaping through the stay holes into the firebox and thence to the atmosphere. When the bulge had extended the full length of the side of the firebox to the back plate and tube plate, these crumpled in and the bulged side appears to have begun to tear away at the two upper corners simultaneously, and after completely tearing along the top, it was driven downwards, hinging along a line level with the top edge of the upper row of rivets attaching the bottom part of the side to the foundation ring, and it appears to have held on at this part until the plate itself had bent through an angle exceeding 180° from its original position. The plate

February 13th, 1907. Six stays on the right side, 2 at the top, and 2 belly stays were found to be broken. No mention, however, is made of the 4 stays on the left-hand side which were found broken at the previous examination and which had not then been renewed.

It was thought by Mr. Laws that the engine went into the shed for repairs about the end of February and came out again on March 23rd, when 43 stays were renewed (11 on the right side, 11 on the left, 16 in the back plate, 5 in the tube plate), and 2 belly stays.

April 10th, 1907. Several tubes were found to be short, and 12 roof stays required renewing. There is no evidence, however, of these stays having been renewed.

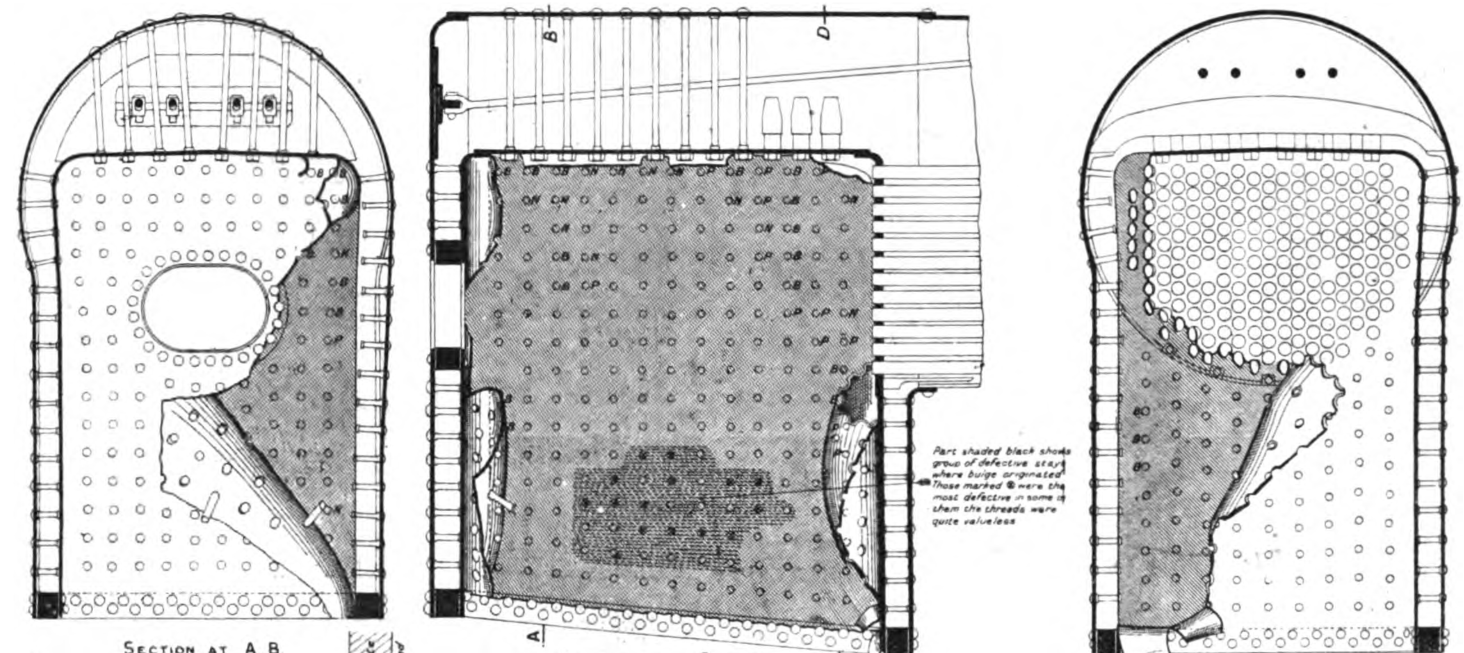
May 1st, 1907. Several stays were reported as having short heads.

May 2nd, 1907. One stay bolt was renewed.

May 17th, 1907. Twenty stays were caulked.

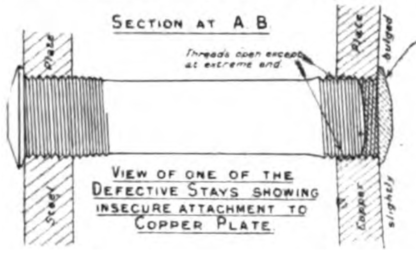
June 3rd, 1907. Reported that the roof bolts required renewing, and that several tubes and 50 stays were short. It is important to note here that previously, on March 23rd, Mr. Laws had reduced the load on the safety valves from 170 to 160 lbs. per sq. in. owing to the condition of the firebox.

The engine continued to work without proper repairs being made to the boiler, and on several occasions when it was out previous to the explosion the drivers found a difficulty in maintaining sufficient steam to haul the usual full load, and the train, which had been marshalled for the engine to take away when the explosion occurred, was composed of only 20 loaded trucks, in consequence of the driver having informed the shunter that the engine was unable to take a full load, which is said to be 26 loaded trucks.



Stays marked with letters denote broken ones. Those marked N appear to be new fractures. Those marked B, old fractures, and those marked P were partly broken before the explosion occurred.

Railway Engineer O.R. 728



was then blown to the left-hand side of the boiler, its flight in that direction being due to the bottom edge remaining attached to the foundation ring until the last. The failure of the side stays described above occurred with extreme rapidity, the whole operation lasting probably less than a second. The driver was found near the left-hand side of the engine fatally injured.

The engine was constructed by Messrs. Kitson and Co., Leeds, in 1901, for a working pressure of 170 lbs. per square inch. Before leaving the makers' works the boiler was tested by hydraulic pressure to 240 lbs. per square inch, or 1·41 times the working pressure only. In 1902 the engine was placed under the charge of Mr. Edward B. Laws, locomotive foreman of the Cudworth District. In 1905 the engine was in the chief repairing shop for a thorough overhaul, since when the repairs done to it have been under the direction and responsibility of Mr. Laws. The latter, in his evidence, gave details of examinations made, and repairs executed to the firebox since December of last year, which are as follows:—

December, 1906, 41 stays renewed, viz.: 27 on the right and 14 on the left side.

January 4th, 1907. It was found that 50 of the ferrules in the tube ends required renewing, and that 4 stays on the right side, 4 on the left, and 2 belly stays were broken. It does not appear, however, that these stays were renewed until the 23rd March.

Another engine driver, named William Peaker, who had worked the engine on several occasions previous to the explosion, had experienced trouble with the boiler and had made several entries in the report book of leakages in the firebox. He had also found it difficult to haul the usual number of loaded trucks.

The firebox was examined on the day previous to the explosion by a boilersmith named Ben Tillotson, at Cudworth, and although he states that he did not think the firebox was in a dangerous condition, he verbally reported to the foreman, Mr. Laws, that it was time the engine went into the shop for a proper overhaul owing to the condition of the stays in the firebox. He further stated that he had previously made a similar report about the boiler to Mr. Laws.

The last time Mr. Laws saw the inside of the firebox was on September 21st, when it was inspected by him in its regular turn. He states that he thought there was nothing wrong with it, but in consequence of Tillotson's report he had arranged that the engine should be sent into the shop as soon as another one, No. 106, which was then being overhauled, was ready to take its place. It would appear, therefore, that he himself was not satisfied with the condition of the boiler that exploded, but no steps were taken to ensure that it was in a safe condition, and Mr. Laws made no special examination of the boiler himself except in its regular turn, which examination must have been somewhat superficial, otherwise it must have been apparent, on consideration, that some of the stays could only have been attached to the plate by two or three threads, or possibly less, as the bulging of the plate between the stay holes—which occurs in nearly all fireboxes after they have been working for a considerable time, and which was visible on the parts of the firebox not affected by the explosion—has a tendency to make the stay holes somewhat conical, thus drawing the threads at

the back of the stay holes away from those on the stays and throwing the load wholly on those at the tips of the stays. Further, the tensile strength of copper falls about 40 per cent. at the temperature to which the ends of the stays are raised in working conditions. It was observed after the explosion that the threads on some of the short stays had practically vanished at the parts in the stay holes owing to continued movement of the plate on the stay, and repeated caulking of the end.

Mr. Stirling, locomotive superintendent, examined the boiler after the explosion, and he stated that the condition of the right-hand side of the firebox was such that if he had seen it before the explosion occurred, he thinks he would not have allowed the engine to go out on the line. The right-hand side of the firebox, however, was not affected by the explosion and was obviously in a better condition than the side that failed. Mr. Stirling was also unaware that the working pressure of the boiler had been reduced.

After the explosion a number of the firebox stays on the left-hand side were found to be broken, chiefly at the two upper corners. Some of them had been broken for a considerable time, others were partly broken before the explosion occurred, and others again appeared to have been broken by the explosion, the fractured surfaces appearing to be quite new. The number of old broken stays and partly broken stays at the upper forward corner had become a matter of serious moment, but the explosion did not occur in consequence of the condition of these stays; the bulge which led to the failure of the side could clearly be seen, upon a close examination of the stay ends and stay holes, to have originated near the bottom where the group of short stays existed, and these stays should have been renewed in June last at the latest; and a serious error of judgment was committed in continuing to work the engine without having had them renewed.

From the evidence given by locomotive foreman Laws and boiler-smith Tillotson, it is clear that both these men were fully aware that the time had come when this engine should have undergone a regular overhaul. Further, the faulty condition in which the right-hand side of the firebox was found after the accident was, as admitted by Mr. M. Stirling, such that the engine ought not to have been sent out on to the line. It is mainly, therefore, to an error of judgment on foreman Laws' part, in allowing this engine to continue at work on the line, that this accident must be attributed.

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At **Kilrane, G.S. and W.R.** *On September 18th. Lieut.-Col. P. G. von Donop, R.E., reports that*:—

The 9 p.m. up passenger train, Kilrane to Wexford, consisting of an engine and 5 vehicles, was run into by a light 4-coupled tank engine fitted with the vacuum automatic and hand brakes on the coupled wheels, from Wexford for Ballygeary.

Both engines were severely damaged, as also was one vehicle of the passenger train. Both drivers and firemen were seriously injured, a locomotive foreman travelling on the light engine was fatally injured, and 3 employees of the Co. were slightly injured. There were no other passengers.

Kilrane Station is on the Wexford-Rosslare branch of the G.S. and W.R. The line is single, and up trains run in the northerly direction. Kilrane is a tablet station, but passenger trains cannot be crossed at it; a goods loop is provided on the east side of the passenger line, so as to enable a passenger train to cross a goods train or a light engine. The loop is, altogether 850ft. long, and the facing points at each end lie normally for the passenger line. On the west side of the passenger line is the platform, 140ft. long.

The next tablet station north of Kilrane is Rosslare Strand, distant 2 m. 607 yds.; and the next tablet station to the south is Ballygeary, distant 1,276 yds. The gradient approaching Kilrane from Rosslare Strand falls at 1 in 1,216 for about 1¼m.

The signal-box at Kilrane is on the east side of the line, 25 yards to the north of the north end of the station platform, and the facing points at the north end of the loop are 155 yds. north of the signal-box.

An up starting signal for the passenger line is fixed on the west side of that line, 16 yds. north of the signal-box; a down home signal for the passenger line, 17 yards north of the facing points at the north end of the loop; a disc signal for entering the goods loop, immediately under the down home signal; a down distant signal 800 yds. north of the down home signal. There is an overbridge crossing the line 770 yds. north of the down distant signal. The south end of the station is similarly provided with home and distant up signals.

The engine of the passenger train was standing almost immediately opposite the signal-box.

A driver approaching Kilrane from Rosslare Strand obtains a good view of his signals, but at the time that the accident occurred the weather was foggy; the evidence as to the density of the fog being, however, somewhat contradictory.

The passenger train had to run "empty" in the up direction from Ballygeary to Kilrane, before starting from the latter place as a regular up passenger train. Accordingly, at 8.49 p.m., the signalman at Ballygeary offered signalman Fitzgerald, who was on duty in the Kilrane signal-box, this empty train, and the latter accepted it forthwith, keeping however both distant and home up signals at "danger," and the facing points at the south end of the loop lying in their normal position, namely, for the passenger line on which the empty train had to run. At 8.54 p.m. the signalman at Rosslare Strand offered Fitzgerald the light engine, and, as the arrangements at Kilrane were suitable for crossing a light engine with a passenger train Fitzgerald accepted it forthwith; he kept, however, both his distant and home down signals and the disc signal for entering the goods loop at "danger," but he left the facing points at the north end of the loop lying for the passenger line instead of for the goods loop, along which the light engine should have run. Both trains therefore were allowed to approach the station simultaneously with the facing points at each end of the loop set for the one passenger line.

The Company's Regulation states that the "line clear" signal should not be given at a crossing station unless the facing points are set for the line on which the approaching train has to run. Fitzgerald clearly did not carry out this Regulation as far as the points at the north end of the station were concerned; his explanation for not doing so is that had he set those points for the goods loop he would have been unable, on account of the interlocking of his levers in the signal-box, to have admitted the empty passenger train into the station. It was found on examination of the interlocking that this was to a certain extent the case, as the up home signal for admitting the up train into the station could not be lowered unless the loop points at the north end of the station were lying for the passenger line. This interlocking is not that which is usually adopted at similar crossing places, and it should be altered; there was, however, nothing to have prevented Fitzgerald from setting the facing points at the north end of the station for the loop before accepting the light engine, and then keeping the empty passenger train outside the station until the light engine had come to a stand at the signals at the north end of the station. There would then have been no danger in shifting the points at the north end of the loop, and lowering the up home signal for the passenger train to draw up to the platform.

From the evidence there can be no doubt that the fog was at times one of considerable density, and the fact that neither of the drivers saw the other engine until the collision actually occurred is strong proof that this was the case. It is probable that, as stated by the harbour-master, it was a rolling fog, and that at times signals were only visible from a very short distance. The conditions appear to be such as to call for the employment of fog-men, and the station-master committed an error of judgment in not calling them out. In this connection it must be noted that it appears from the evidence that fog-men and fog-signals have never been made use of at this station at all. This seems strange, as fogs are undoubtedly prevalent in the locality. The matter is worthy of the Company's attention.

It is probable that the speed of the light engine at the facing points was considerably over that estimated (18 miles an hour) by driver Duggan, and under those circumstances it certainly appears that he failed to exercise proper care in approaching the station.

It transpired that the disc signal for entering the goods loop is not usually made use of, but that it has been customary for the signal for entering that loop to be given by a hand signal from the signal cabin. It was further admitted that on the night in question, as well as on previous nights, there was no lamp in this disc signal, so that at the time of the accident it could not possibly have been made use of. The fact of this disc signal not having been made use of appears to have been another contributory cause of this accident. Driver Duggan, who was in charge of the light engine, states that he always relied on receiving a hand signal from the signal-box for entering the goods loop, and that that hand signal was sometimes given without the disc signal being made use of at all. On this occasion he expected to be put into the goods loop in order to cross the passenger train. As the disc signal was not lighted, he should, according to Rules, have treated that signal as being at "danger," but it is evident that, knowing that the disc signal was not usually made use of, he disregarded the fact of its not being lighted, and ran on, expecting to find that a hand signal was being given him from the signal-box.

Signalman Fitzgerald states that the reason for not making use of the disc signal was that it was out of order; but he admits that he had never reported this fact to anyone. Mr. O'Callaghan, the stationmaster at Kilrane, states that it had once been reported to him that the disc signal was out of order, but that on receiving this report he examined the signal and satisfied himself that it was working all right. Signal-inspector Talbot states that he has no recollection of ever receiving any notification that the disc signal was not in working order. A few days after the accident he came to Kilrane to examine the signals, but his visit was not made on account of his receiving any special report concerning them. He states that before doing anything to the signals he tried them, and he found that they were working correctly. He allows that subsequent to examining them he oiled them, but he states that, as far as he was aware, there was nothing wrong with the disc signal on his arrival. From this evidence it appears to me to be very doubtful whether there was anything amiss with the working of the disc signal, but, if there were any defect in it, the responsibility lies on the station officials for not having taken proper steps to report the matter to the Signalling Department.

As regards there being no lamp in the disc signal, signalman Fitzgerald states that there was no lamp available for the purpose, and that it was on that account that he had always given a green hand-light to the driver for entering the loop. Mr. O'Callaghan, the stationmaster, admits that he knew that it had not been the custom to light the disc signal, the reason being that they were short of lamps. He states that he had telephoned to Waterford for additional lamps, but he admits that he had never reported the matter formally to the signal inspector. There is no doubt that there was a deficiency of lamps at the time of the accident, and for this again the station officials must be held responsible.

It is evident that the working at Kilrane Station has been carried out, in several respects, in a very irregular manner, and that this accident was, to a great extent, due to these irregularities. The management of the station certainly seems to call for some special supervision on the part of the Company.

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THE Railway Engineer

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Contents.

Lord Cottesloe has, on account of advancing age, resigned the chairmanship of the L., Brighton and South Coast R., which position he has held for 11 years, and the **Rt. Hon. Earl of Bessborough**, director, has been elected to succeed him. Lord Cottesloe does not, however, leave the Board.

Lord Kenyon, of Gredington, North Wales, has been elected a director of the L. and North Western R. in place of **Sir Thos. Brooke**, who has retired.

Mr. Chas. Poston, director, has been elected deputy chairman of the Hull and Barnsley R. in succession to **Mr. Wm. Trotter**, who has resigned.

Mr. Harry Wainwright, locomotive engineer to the South Eastern and Chatham Joint Managing Committee, has had the 4th Class of the Order of the Royal Prussian Crown conferred upon him by the German Emperor.

Mr. C. Lowndes, district superintendent of the L. and North Western R. at Birmingham, has been appointed to succeed the late Mr. H. Linaker as district superintendent at Manchester; **Mr. L. W. Horne**, district superintendent at Chester, succeeds Mr. Lowndes at Birmingham; and **Mr. Warner**, who has for some time been Mr. Turnbull's outdoor assistant at Euston Station, succeeds Mr. Horn at Chester.

Mr. J. E. Leggatt, chief clerk in the rates department of the general manager's office, has been appointed goods manager of the Midland Great Western R. of Ireland in succession to the late Mr. Morrison.

Mr. E. H. Hiley, chief passenger agent, Great Northern R., has been appointed district goods manager of the North Eastern R. at Hull from the 1st April, when **Mr. A. E Ballan** retires, and **Mr. D. C. Adam**, assistant district superintendent at Hull, has been appointed dock superintendent.

An advisory committee, consisting of **Messrs. Edwin Waterhouse** (chairman), **Mr. Spencer Phillips, Mr. Marlborough Pryor, Mr. Thomas Skinner**, and **Mr. John Akroyd**, with **Mr. Lynden Macassey** as secretary, has been formed for the purpose of considering, in conjunction with the board and Messrs. Speyer, a scheme dealing with the profit-sharing secured notes and the financial requirements of the Underground Electric Railways Company of London, Ltd.

Since our last issue several prominent men in the railway world have passed away. **Sir Henry Whatley-Tyler** died at his residence in London on 30th January, in his 82nd year. He was deputy-chairman of the Great Eastern R., chairman of the Westinghouse Brake Co. and the Peruvian Corporation and most of its railways, besides being on the directorates of several other companies. He was chairman of the Grand Trunk R. of Canada from 1875-95. He was formerly in the Royal Engineers, and became Chief Inspector of Railways at the Board of Trade.

Mr. R. J. Morrison, goods manager of the Midland Great Western R. of Ireland, died at Dublin on 30th January. He entered the old Belfast and N. Counties R. in 1871. In 1891 he was appointed goods superintendent at North Wall for the Midland Great Western R., and in 1893 goods manager.

Lt.-Genl. Sir Richard Strachey, G.C.S.I., died on the 12th ultimo, at the age of 91. In 1871 he was appointed Inspector-General of Railway Materials and Stores at the India Office, and was for many years chairman of the East Indian and the Assam-Bengal railways.

Mr. Cornelius Lundie, consulting director, and formerly for 43 years general manager, of the Rhymney R., died on the 12th ultimo, at the age of 93, at Cardiff.

Mr. Alfred Baldwin, chairman of the Great Western R., died very suddenly of heart failure on the 13th ultimo. He had attended a board meeting of the Company, and was to have presided at the half-yearly meeting on the following day. He left Paddington in a hansom cab, and drove to his residence at Kensington Palace Mansions. He ascended the steps and reached the hall without assistance, but was taken ill directly he entered, and expired in 20 minutes. He was born in 1841, and was the youngest son of the late Mr. G. P. Baldwin, iron founder, Stourport. He entered business early in life, and in 1902 he combined his business with several others into Baldwin's, Ltd., with a capital of £1,100,000, and of which he was chairman. He joined the board of the Gt. Western R. in 1901, and succeeded Lord Cawdor as chairman in 1905. He was also chairman of the Metropolitan Bank (of England and Wales), Ltd. He was M.P. for Worcestershire (Bewdley division) since 1892.

Mr. Wm. Greenaway, chief inspector, loco. department, Gt. Western R., died on the 20th ultimo at Swindon, aged 64. He had been in the service of the company 40

years. He was generally on the engines of important Royal specials, including the late Queen Victoria's jubilee and funeral trains, also when the Prince of Wales was taken from Paddington to Plymouth—246 miles in 234 minutes—by the "City of Bath."

*

Board of Trade Railway Enquiry.

It is evident from the utterances of railway chairmen that they did not want "conciliation" and that the agreement was only accepted under threats of drastic legislation flavoured with specious promises of an enquiry with a view to ameliorating the unsatisfactory conditions under which railway companies are compelled to work. A conference to investigate the railway services of the country and the relations of the railways to commerce has been got together by the President of the Board of Trade. It consists of the following members :—

Representing the Board of Trade :—Mr. D. Lloyd-George, chairman; Mr. Hudson Kearley, M.P., Parliamentary Secretary; Mr. H. Llewellyn Smith, C.B., Permanent Secretary; Mr. G. R. Askwith, K.C., Assistant Secretary in charge of the Railway Department.

Representing the Railways, general managers nominated by the Railway Companies' Association :—Sir C. J. Owens, South Western R.; and Messrs. A. Beasley, Taff Vale R.; A. K. Butterworth, North Eastern R.; Sam Fay, Great Central R.; W. Guy Granet, Midland R.; J. C. Inglis, Great Western R.; and W. F. Jackson, North British R.

Other Members, selected by Mr. Lloyd-George :— Mr. Frank Forbes Adam, ex-president of the Manchester Chamber of Commerce; Sir W. T. Lewis, a large coalowner; Mr. W. Burton, general manager of an important firm in the Potteries; Mr. Ratcliffe Ellis, secretary, Coalowners' Association; Mr. O. D. Johnson, representing agriculture; Mr. W. H. Mitchell, J.P., vice-president, Associated Chambers of Commerce; Mr. Alfred Mond, M.P. (Brunner, Mond, and Co.); Mr. E. Moon, K.C.; Mr. Alexander Siemens (Siemens Bros. and Co.); and Mr. J. A. Spender, editor of the *Westminster Gazette*. We presume the last-named represents the interests of the-man-in-the-street. The results of the enquiries and deliberations of this conference will be awaited with much interest, as it seems evident that what the Board of Trade wants to find out is whether the railways can be given anything which they can hand over to the traders. The object of the advanced section of the present Government appears to be to reduce—by any means—the railways to a non-paying condition with the ultimate object of buying them at a low price.

The Nationalisation of Railways was recently debated in the House, and Mr. Lloyd-George said he had come to the conclusion that our railways do favour the foreigners in the matter of rates. Those who have studied the question at least as long and probably more deeply have arrived at a different conclusion. And when cases have been brought before the Railway and Canal Commission the companies have usually been able to justify any difference in the rates by difference in the services rendered due to packing, handling and loading, and by the regularity and size of the foreign shipments. One of the great differences between foreign shipments and inland shipments is that there are no returned empties for the former. One has only to stand in a goods depôt, *e.g.*, the tranship shed at Crewe for a short time to get a good idea of the extra labour which "returned empties" throw upon railway companies. In many cases the empties are not worth the carriage, and when they are they often weigh nearly as much empty as full, and, with the exception of sacks and such like, occupy as much space and necessitate as much clerical labour. All this has to be paid for, and the rate on the goods must and does include it. Take for example pianos. The case which the German instrument is imported in is not returnable for love or money, whereas the travelling case of the English instrument is returned as if it were made of gold. The same remarks apply to flowers, fruit, bicycles, hardware, pottery and hundreds of other articles.

The abolition of the private owners' wagons is another subject which should engage the attention of the conference, but it is really only another phase of the "returned empty" question, aggravated by the fact that most of the wagons are not owned by shippers, but by middle men, who make huge profits which the man-in-the-street thinks go into the pockets of railway shareholders.

*

To the House of Lords for 6s. 6d.

It is to be hoped that there was some great principle involved in the case which the House of Lords decided on the 4th ultimo, the facts of which are briefly as follows :—In October, 1905, Messrs. Phillips and Co., Ltd., sent a truck of coal to Loudwater and then ordered the empty to the Blaen-cae-Garwen, S. Wales, colliery to be filled and sent to a customer at Hampden-in-Arden. The Gt. Western R. Co. made no charge for taking the empty to S. Wales, but there was some delay in doing so and they offered to pay 6*d*. per day demurrage for the 4 days. But Messrs. Phillips said that to fill their contract they had been obliged to hire an emergency wagon at a cost of 8*s*. 6*d*., which they demanded and which the Gt. Western R. refused to pay and were sued therefor in the Marylebone C.C. But the judge decided that he had no jurisdiction to settle the matter, as it was one which the G.W.R. Rates and Charges Act, 1891, said should be settled by an arbitrator appointed by the Board of Trade. This decision was unanimously upheld by the House of Lords and an arbitrator can now be appointed to settle whether the G.W.R. Co. shall pay 8*s*. 6*d* or 2*s*. This is the kind of case that is constantly arising out of the system of private ownership of wagons in vogue in his country.

*

Right to Increase Coal Carriage Rates.

The main reason why railway companies are unable to reduce their rates in bad times is that they are seldom allowed to ever raise them again. There are, however, exceptions. On the 12th ultimo the Railway and Canal Commission decided that the North Staffordshire, the L. and North Western, and the Gt. Western railways were justified in raising their rates from certain collieries in North Staffordshire to Birkenhead and Ellesmere Port, and dismissed (by a majority) with costs the application of the North Staffordshire Colliery Owners' Association.

A group rate had been in force to the ports on the Mersey for years before the reduction took place in 1895, when at the earnest solicitation of the colliery owners it was reduced in order to keep the pits open. The price of locomotive coal

was then 6*s.* 9*d.* per ton. In 1900, when the Boer war was proceeding, and everything connected with railway working increased in price, locomotive coal being 14*s.* 3*d.* per ton, the rate was raised to the old level. In 1904 the rate was again reduced to the 1895 level, except to the two ports above-named, and it was against this increase that the unsuccessful application was made to the Court.

*

German State Railway Methods.

DURING the enquiry into the alleged South African shipping ring, Sir Donald Currie gave an emphatic denial to the statements that British shipowners charge lower rates from Continental than from British ports, and said that "the State "railways of Germany allow to the German East African "Mail Line exclusively reduced railway carriage rates from "inland towns upon German manufactured goods, provided "they are shipped at Hamburg by the steamers of the German East African Line, which sail under the German flag, "and not by British steamers." Continual protests have been lodged with our Government and with the German lines, which have rate arrangements with the British lines, against such unfair treatment, but of course without result. These inland rates to Hamburg often enable merchants to place orders, which ought to be executed in this country, with German manufacturers. These are the kind of tactics that Mr. Lloyd-George expects our railways to compete against. We wonder what would be said if one of our railway companies proposed to give special export rates provided the goods were shipped by a particular line of steamships!

*

"Tips" are Wages.

A CASE of some importance to railway companies has been recently decided by the Court of Appeal.

A waiter named Williams, in the employ of Spiers and Pond, Ltd., was killed when on duty on a restaurant train on the L. and South Western R., on which the defendants are refreshment contractors. The defendants admitted liability under the Workmen's Compensation Act, 1906, to pay compensation based on the "earnings" at the rate of 25*s.* weekly, but the man's child claimed that the "tips" his father received were 10 to 12*s.* a week more.

The Master of the Rolls (Lords Justices Moulton and Buckley concurring) said the Wandsworth C.C. Judge had rejected the applicant's claim on two grounds: first, because "weekly earnings" meant earnings between employer and employee and nobody else; secondly, because the evidence did not show any express and distinct bargain, as opposed to an implied bargain, that the employee should retain the tips in addition to his wages. In the opinion of the Court, neither of these propositions could be supported. Where the employment was of such a nature that the habitual giving and receiving of tips was open and notorious, and sanctioned by the employer, the money so received should be included in estimating the "average weekly earnings" of the servant.

*

Result of Removing the Coal Tax.

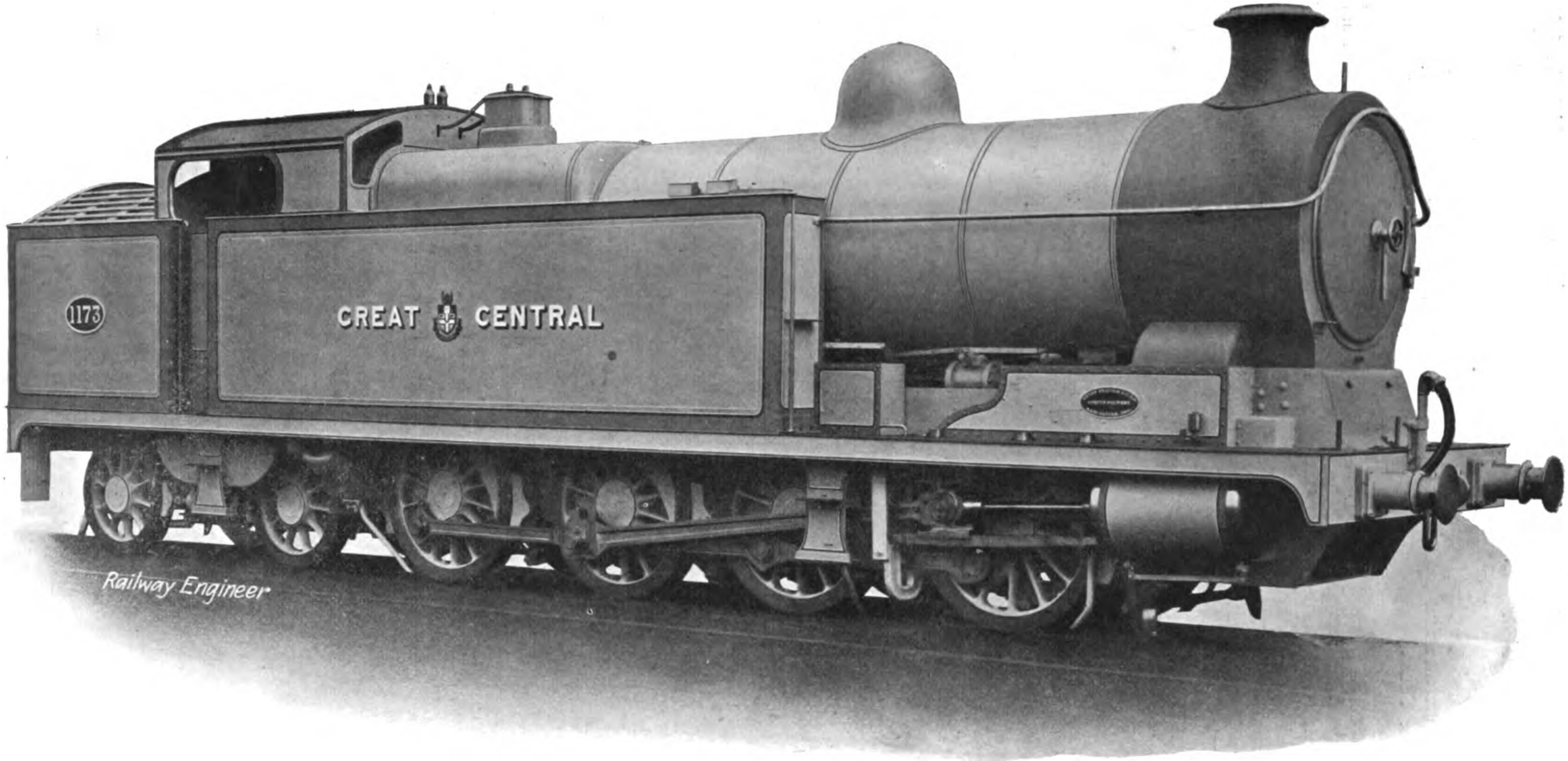
THERE can be no doubt as to the result of removing the export duty on coal. The Continental demand, especially from Germany, for our coal has been enormous, and the factories and railways there have been worked more cheaply than they could have been without our coal, but in our own country only the miners and colliery owners have benefited by the high prices everyone has had to pay. The coal bills of the principal railways for the past half-year show the following increases:—

L. and North Western, £157,467; Gt. Western, £67,128; North Eastern, £43,679; Gt. Central, £50,639; Gt. Northern, £48,000; Gt. Eastern, £43,188; Lancs. and Yorks, £36,541; L. and South Western, £36,420; South Eastern and Chatham, £31,000; L. Brighton and S.C., £10,953; Midland, £89,018.

These increases are of course partly due to increased train mileage, *e.g.*, the North Western R. ran 395,724 more passenger and 733,653 more goods train miles and the Great Western R. 545,764 more passenger, 188,578 electric, 30,372 rail motor and 342,914 goods train miles, but the Brighton Co. consumed rather less coal.

The All-British Route from Euston to Japan.

WE reproduce herewith a particularly striking poster which has been issued jointly by the L. and North Western and the Canadian Pacific railway companies, with a view to popularise the "All British" route to the East viâ Canada. It is also hoped by this means to foster trade viâ the Canadian Pacific R., as the trains and steamers connect closely, the sailings are frequent, the fares inclusive, the scenery beautiful and grand, and the accommodation luxurious. Descriptive pamphlets can be obtained at all the principal offices of the L. and North Western and Canadian Pacific railways.



0-8-4 Three-Cylinder Shunting Tank Engine for Wath Concentration Yard, Great Central Railway.

Constructed by Messrs. Beyer, Peacock and Co., Ltd., to the designs of Mr. J. G. Robinson, M.Inst.C.E., Chief Mechanical Engineer.

Cylinders (3) 18in. diam; 26in. stroke. Wheels (8-coupled) 4ft. 8in. diam., bogie 3ft. 7in. diam.; tyres 3½in. thick.
Boiler 5ft. diam., 15ft. long; firebox 8ft. 6in. long; steel tubes (221) 2in. diam., 15ft. 4¾in. long.
Heating surface, firebox 153 sq. ft., tubes 1,778 sq. ft., total 1,931 sq. ft. Grate area 26 sq. ft. Working pressure 200lbs. per sq. in.
Tank capacity 3,000 gallons; bunker capacity 4 tons.
Drawbar pull up to 10 miles per hour, 13 tons.
Weight fully loaded on coupled wheels 73 tons 12 cwt., on the bogie 22 tons 19 cwt., total 96 tons 11 cwt. Weight empty 74 tons 1 cwt.
Wheel base, coupled 17ft. 1in., of bogie 7ft. 6in., total wheel base 30ft. 8in. Length over the buffers 45ft. 0½in.

New North Western Irish Service.

LORD STALBRIDGE, at the half-yearly meeting of the L. and North Western R., announced that on the 1st April the day service between Holyhead and Dublin would cease to run to and from North Wall, and would be transferred to Kingston. The new train in connection will leave Euston at 1.20 p.m. and the passengers will arrive at Kingston at 9.50 p.m., and in the other direction the North Western express steamer will leave Kingston at 1.45 p.m., the passengers arriving at Euston at 11 p.m. The night service to and from North Wall will not be altered *for the present.*

The company have apparently been driven away from Dublin by the Port and Docks Board, who seem to have thought that the L. and North Western R. was a "Saxon" company that might be milked, so they framed a new schedule of dues, by which the payments by the L. and North Western R. were to be raised from £12,000 to £24,000 per annum, and all other interests left practically untouched. As the company is suffering from want of berthing accommodation at Dublin the removal of two boats to Kingston will give relief, and at the same time the alteration of the times of departure will be more convenient for the public, especially business men and those passengers from beyond London and the interior of Ireland. Incidentally the new service will benefit the Dublin and South-Eastern R., in which the L. and North Western have a large interest, and compete for this traffic more effectively with the Fishguard route.

*

North British and Caledonian Agreement.

THE directors of the Caledonian R. held a rather unique meeting recently, when 75 station-masters and traffic inspectors were in attendance in the Board room. The subject of discussion was the new agreement with the North British R. and the working of the traffic in connection therewith. The idea was to get an expression of opinion from the officials directly concerned with the controlling of the traffic, so that a proper understanding could be arrived at among all concerned. In this respect the meeting was a most successful one, and it is to be hoped the directors will have realised the importance of having more of such meetings. Good results can only follow bringing the directors and such officials in closer touch upon all questions affecting the better working of the system.

*

L. and North Western Board.

THE Chairman announced at the half-yearly meeting that it was not intended to fill the vacancy caused by the retirement of Mr. Wm. Louther, and that when another vacancy occurs the shareholders will be asked to reduce the number of the directors to twenty.

*

Cordingley's Motor Show.

ON the 21st inst. Cordingley's 13th International Motor Exhibition will open at the Agricultural Hall, London, and close on the 28th inst. Both business and pleasure vehicles will have a large display; not only will many new types of British automobiles be seen for the first time, but several important newcomers are expected from the Continent. The display of heavy vehicles will be comprehensive.

*

New Motor Speed Records.

ON the 18th ultimo at the Brooklands Racing Track Mr. F. Newton, on a 60 h.p. Napier car, created five new speed records, viz. :—50 miles in 35m. 7·36sec (85·413m. p.h.); 100 miles in 70m. 20·31sec. (85·302m. p.h.); 150 miles in 106m. 6·17sec. (84·82m. p.h.); 1 hour, distance covered 85m. 555yds.; and 2 hours, distance covered 169m. 615·6yds.

*

North Eastern Railway Receipts.

LAST half-year the receipts of the North Eastern R. exceeded £10,000,000 for the first time in the history of the company.

0-8-4 Three-Cylinder Shunting Tank Engines, G.C.R.

THE annexed illustrations show the heaviest and most powerful shunting engines at work in this country.

In our issue for last May we gave a diagram and some particulars of these engines, which had then recently been designed by Mr. John G. Robinson, M.Inst.C.E., chief mechanical engineer of the Great Central R., and which were being built by Messrs. Byer, Peacock and Co., Ltd., at Gorton. One of these engines has been delivered and has for some weeks been doing the particular work at the Great Central R. Co.'s New Concentration Yard at Wath*, for which it was designed, and its performance has more than fulfilled its designer's expectations.

The Concentration Yard at Wath is laid out on the "hump" plan, and it is the duty of these engines to push trains of 70 wagons (about 1,050 tons) up a gradient of 1 in 109 to the top of the "hump" so that they may gravitate to the "gridiron" sorting sidings.

In this work the engine, of course, gets no assistance from slack couplings, and must have great adhesion power and a constant and equal turning effort at the cranks. For these reasons three simple cylinders, with their cranks set at 120° to each other, were adopted, as such an arrangement gives a more equal turning effort than either two or four cylinders do. The maximum variation in full gear is only about 5% on either side of the mean, so that the engine has the starting and non-slipping qualities of an electric locomotive.

Another great advantage of this arrangement is that it enables the principal parts to be interchangeable with existing classes of Great Central engines, *e.g.*, the boiler is exactly similar to those of the "Atlantic" engines; the wheels, axles, axle-boxes, coupling and outside connecting rods, and motion are exactly like those of the 8-coupled mineral engines; and the inside motion is similar to that of the latest class of 6-coupled goods engines.

The work is intermittent, and therefore it was not necessary to provide the boiler with more than sufficient heating and grate surface. The weight is made up by ample capacity for water and coal. It might be thought that such large tanks were not necessary for an engine intended to work in a yard well provided with water cranes, but it must be remembered that axle loads are of less moment on the Wath sidings than they are on the running lines.

The quick handling of these engines is ensured by Mr. Robinson's steam and cataract reversing gear, which we shall illustrate in detail, with general sectional drawings of the engine, in our next issue.

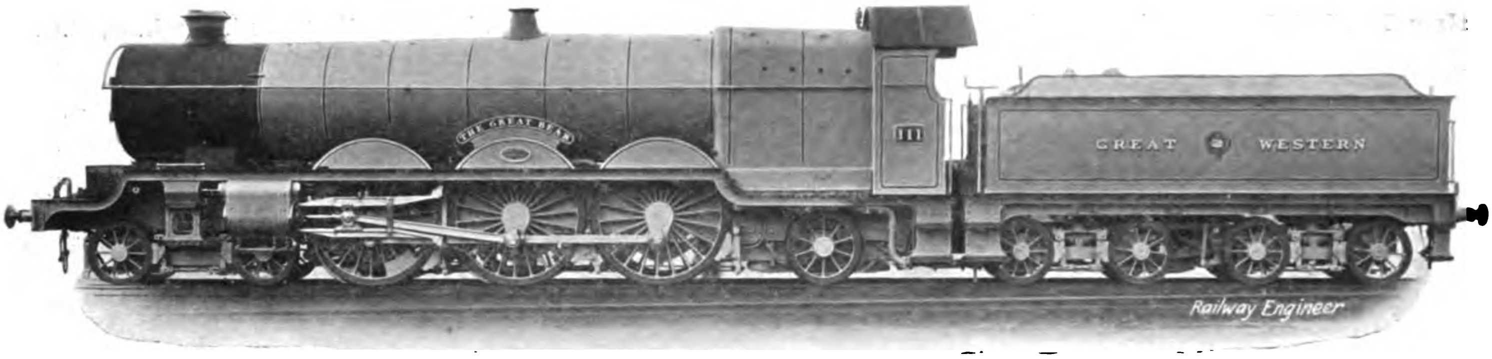
All the wheels (including the bogie wheels) are braked, the pressure being applied by steam controlled by a valve worked either by hand or with the vacuum brake.

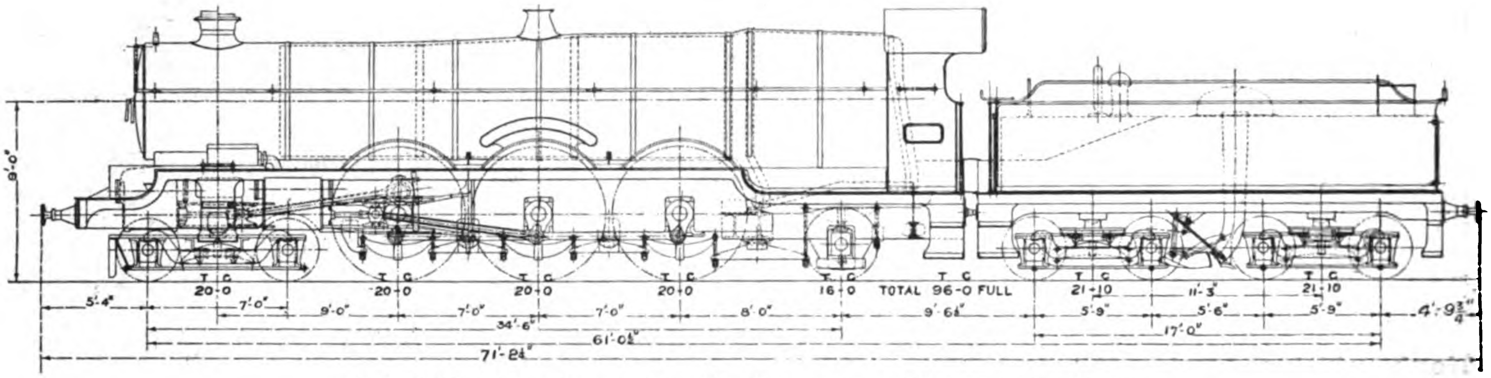
In connection with this engine it may not be out of place to draw attention to the great increase in the tractive power of the goods engines on the Great Central R. in the last few years. The first engines designed by Mr. Robinson for the railway were the powerful 6-coupled goods engines known as the "973" class, and which came into service in September, 1901, and had a greater haulage capacity by 15 % than the most powerful goods engines then on the railway. In November, 1902, the 0-8-0 type with outside cylinders, and known as the "1052" class, commenced working the heavy mineral traffic. These engines developed a tractive power 50 % greater than those of the "973" class. Finally the engines for Wath have a tractive effort 50 % greater than the "1052" engines.

Engine Renewals, G.C.R.

THE chairman, Sir Alex. Henderson, Bart., stated at the half-yearly meeting that during last year 35 new engines, weighing 2,402 tons, had been turned out on revenue account at Gorton to replace 35 old engines, weighing 1,732 tons. Also that 87 new boilers were fitted as against 45 in 1906.

*Fully described and illustrated in *The Railway Engineer*, March, 1907.





4-6-2 Express Passenger Engine; Great Western Railway.

THE largest and most powerful express engine ever built for service in this country was turned out of the Swindon works of the Great Western R. last month. It has the 4-6-2 or "Pacific" wheel arrangement, and, as will be seen from the annexed illustrations—for which we are indebted to the courtesy of Mr. G. J. Churchward, M.Inst.C.E., who designed the engine—that it has a handsome appearance, notwithstanding its great length and the restrictions imposed by the limitations of the load gauge.

The engine has four (simple) cylinders, and as regards the motions Mr. Churchward has followed closely the arrangements he designed for the "Star" class. The inside cylinders drive on to the leading (cranked) coupled axle and the outside cylinders on to the middle coupled wheels. All the valves are of the piston type, and are worked by two sets of gear arranged inside the frames. The method of working the two valves by one gear is not unlike that adopted by the late Mr. Webb for some of his compound engines, but the disadvantages of the system do not apply to pairs of simple cylinders which are, so to speak, only divided for convenience and do not require their cut offs differentiated.

The engine is fitted with the "Swindon" superheater, the working pressure being 225lbs. per sq. inch.

The boiler barrel has coned rings 6ft. to 5ft. diam. and a wide firebox with a short inclined front "leg." It is, we believe, the largest locomotive boiler yet built for such a high working pressure.

The weights given on the diagram are "estimated," but the actual weights do not, we understand, differ very materially therefrom, the total actual weight of the engine being 97 tons 5 cwt. and that of the tender (maximum) 45 tons 15 cwt., total 143 tons.

The tender is mounted on two 4-wheeled bogies, and is the first of the kind ever built for the Great Western R. It is, however, when compared with the tenders on other lines, remarkably small for the size of the engine. This is, of course, due to the fact that the Great Western R. is now well equipped with water troughs.

The principal dimensions are as follows :—

Cylinders (4): 15in. diam. by 26in. stroke; steam ports 25in. by 1¼in.; exhaust ports 25in. by 3in.

Wheels: Bogie 3ft. 2in.; coupled 6ft. 8½in.; trailing 3ft. 6in.

Boiler Barrel: 5ft. 6in. and 6ft. outside diam. by 23ft.

Firebox Shell: 6ft. 6in. and 5ft. 9in. by 8ft. long outside.

Firebox Inside: 5ft. 8⅜in. (front) and 4ft. 11⅛in. (back) by 7ft. 2⅜in. by 6ft. 5 1/16in. (front) and 5ft. 2 7/16in. (back) high inside.

Tubes: 84 superheater tubes 1⅜in. diam. by 21ft. 4in.; 141 fire tubes 2½in. diam. by 22ft. 7in. long; 21 fire tubes 4¾in. diam. by 22ft. 7in.; 4 arch tubes 3⅜in. diam. by 7ft. 8½in. long.

Heating Surface: Superheater tubes, 545 sq. ft.; fire tubes, 2,673·45 sq. ft.; arch tubes, 24·22 sq. ft.; firebox 158·14; total 3,400·81 sq. ft.

Fire Grate Area: 41·79 sq. ft.

Working Pressure: 225lbs. per sq. inch.

Tender: Capacity of water tanks, 3,500 galls.

Tractive Effort: 29,430lbs.

Heavier Rails, Belgian State Railways.

As axle-loads and the speed of trains are increased so must the permanent-way be strengthened. The Belgian main lines are laid with the Vignoles rails, weighing 40 kilos per mètre (about 83 lbs. per yard). As the axle-loads of the Belgian locomotives have been increased considerably, the management propose relaying the lines with rails weighing 56¼ kilos per mètre (about 108 lbs. per yard). This heavier rail is to be laid on the line from Liége to the German frontier, and the section between Liége and Welkenraedt has been already so relaid. Anyone who has recently travelled by express trains over the Belgian State railways must have recognised that, according to British ideas, the rails were too light.

Notes on the Erection of Bridges—IX.*

H. Miscellaneous (continued).

The New Redheugh Bridge.

This bridge consists of two channel spans of 252ft. each two shore spans of 170ft. each, and the total length, including the approaches, is 1,190ft.

The new bridge replaces an earlier structure in which the upper boom of the girder was a pipe actually used for the conveyance of water, and being 24ins. in diameter, the bottom boom being similarly used for the conveyance of gas, and being 27ins. in diameter.

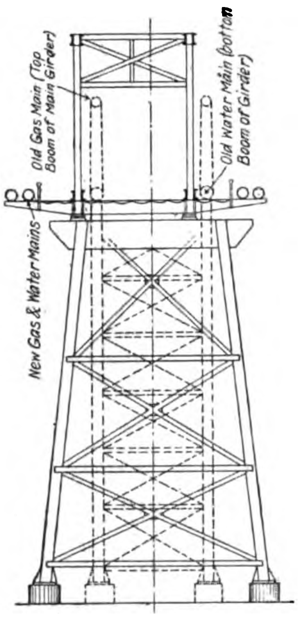


Fig. 24.—Redheugh Bridge between Newcastle & Gateshead.

It was an essential condition that the gas and water pipes should not be disturbed until the new pipes carried on the new structure were ready to replace them, and this demanded an exceptional treatment in the erection of the new bridge. Fig. 24 shows the old and the new structures, the old in dotted and the new in firm lines. The new piers were erected over and around the old piers, and the girders were erected by building them out simultaneously from each of the piers as a cantilever structure, but 4ft. 6ins. out of the centre line, which is the same in both the old and new bridges.

When the girders were complete they were moved sideways one at a time into their final position, the old structure being at the same time removed.

Saint Just Bridge.

This bridge carries a road over the river Ardèche in France, and has six openings, each 164ft. from centre to centre of piers, spanned by wrought iron arched ribs, five ribs being placed in each span.

In this case, owing to the river bringing down boulders, etc., when in flood, a temporary staging resting on the bed of the river was deemed inadvisable, so that a pair of timber trusses, each 18ft. in depth, were constructed and rolled over the piers to form the stage from which the permanent arched ribs were supported.

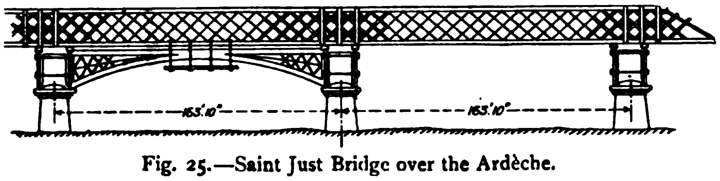


Fig. 25.—Saint Just Bridge over the Ardèche.

Large rollers were placed upon the piers and abutments, and rails were laid along the top of the timber trusses, upon which travelling cranes to lift the ironwork for the permanent work were arranged to run.

Two openings were spanned by the protruding temporary trusses, the one span when finished acting as an anchorage for the overhanging weight suspended in the adjoining span.

In this manner the 600 tons of wrought iron work in the permanent structure were erected.

El Kantara Bridge in Algeria.

This bridge has a clear span of 184ft., and as the height was no less than 393ft. ordinary staging could not be used.

A light platform was suspended across the gorge by means of chains securely anchored down on the suspension bridge principle; and light arches, made suitable to the intrados of the permanent arched girders, were used as the staging or centreing.

The temporary arches were made of sufficient stiffness not to change their shape during the erection of the permanent work upon them, and upon the same principle this stiffness was also available to prevent the cranes supporting the platforms also from altering their shape.

This method of supporting a centreing or falsework has not proved available for use elsewhere, the heavy masses used in bridge work having too great a tendency to distort the flexible chains supporting the stage.

The bridge was built in 1866.

Cantilever Bridge over the Seine at Paris.

The method of erection of this bridge is shown in fig. 26.

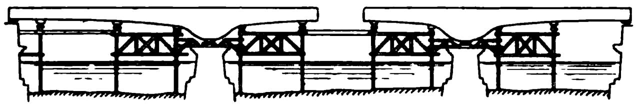


Fig. 26.—Cantilever Bridge over the Seine at Paris.

The central span is 124ft. 8ins., and the two end spans 91ft. 10ins.

Koningswart Bridge.

This bridge was constructed in 1875 and carries a railway line across the river Tun in Bavaria, and is at a height of 160ft. above the water level.

The three main spans are of 227ft. from centre to centre of the piers, and as the piers are of masonry a scaffolding was put up for them in the first case and subsequently used for the support of the superstructure. Midway between the scaffoldings for the piers another staging was put up, and two openings were thus left in each span of 81ft. in the clear.

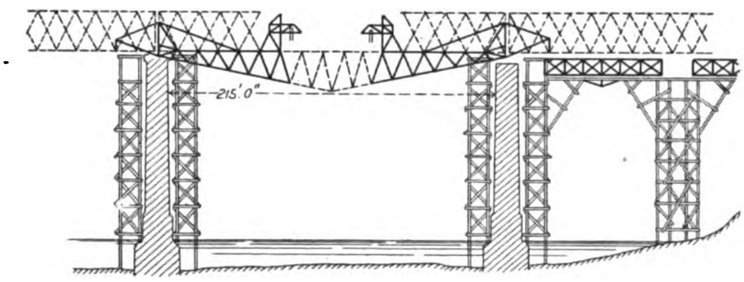


Fig. 27.—Koningswart Viaduct over the Tun.

Wrought iron lattice girders were now placed upon the piers of scaffolding and a timber floor was erected upon the temporary girders, and upon this the permanent bridge was built.

This refers to the two side spans, and a central scaffolding was also erected in the middle span, which was destroyed by one of the floods so prevalent in the country.

A temporary wrought iron framework stretching across the whole of the middle span was therefore provided, and as the two side spans had by this time been erected, the wrought iron framework for the middle span was anchored down to

*The previous articles of this series appeared in the *Railway Engineer* of the following dates:—I., December, 1905; II., November, 1906; III., April, 1907; IV., June, 1907; V., August, 1907; VI., October, 1907; VII., November, 1907; VIII. January, 1908.

the girders of the side spans, and was built out from each pier as a cantilever until the two ends met in the centre of the span. The anchorages at the ends of the temporary girder so erected were provided with adjusting screws and universal joints to provide for a sufficient movement to bring the two meeting ends together in the middle of the span.

Small swing cranes were used as the building out was completed, and moved along to the end of the cantilevers, and in order to make the stress upon the anchorages as small as possible only about one-third of the central portion of the temporary girder was erected at first until the junction was made.

When the junction was complete the remaining bars in the central part of the temporary girder were fixed, as was also the timber floor, and the whole girder and platform was lowered six feet so as to be at the right level for the permanent girder.

The weight of the temporary framework was 84 tons, the clear opening was 215ft., and the load provided for was 2 tons per lineal foot. A higher co-efficient of unit stress was permitted in this temporary girder than had been allowed in the permanent girder.

Whilst the two halves of the temporary girder were being constructed as cantilevers a maximum stress of 7·62 tons per square inch was allowed, but after the two cantilevers had met in the middle of the span a stress of 10·16 tons per square inch was allowed during the subsequent erection of the permanent girders.

Arched Viaduct over the Seine, Paris.

This arch has a span of 279ft., and the platform is suspended from the ribs, which are provided with steel hinges at each end.

Owing to the requirements of the navigation it was only possible to provide scaffolding for parts of the span, leaving one opening of 89ft. in the centre of the span. The girder

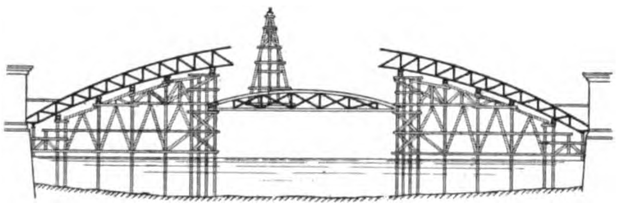


Fig. 28.—Arched Viaduct over the Seine, Paris.

over the latter (fig. 28) was carried to the site on a scaffolding made to rest upon two barges, which, after attaining their proper positions, were loaded with ballast so as to sink the barges the requisite depth to place the service girders on their bearings.

The various portions of the arched ribs were put in place with the assistance of a gantry, by which the pieces were lifted direct from railway trucks and placed in position by means of two winches.

Pont du Carrousal.

This bridge was erected in 1834-36, and the cast iron arched ribs were supported by a clustered staging. There were three openings, each of 157ft. span, and these openings were sub-divided into bays of 44ft., 69ft., and 44ft. by two rows of close or clustered supports 43ft. in length.

The rows consisted of thirty-six timbers, twenty-four of these being upright and twelve others placed at an inclination so as to prevent movement sideways. This bridge is over the Seine at Paris.

Erdre Bridge.

This was a single arched double line railway bridge of 321ft. span over the river Edre at Nantes. The supports of the staging were placed 26ft. apart except in the centre of the span, where an opening of 40ft. was left for the passage of river traffic. The height of the crown of the arch from the ground was only 56ft.

Thames Bridge at Blackfriars Station.

This bridge carries seven lines of railway and has five spans, one of 183ft., two of 185ft., and two of 175ft., and in this case the arched ribs are sufficiently stiff in themselves and no spandril bracings between the arch rib and the horizontal longitudinal girder are provided.

The ribs were brought to the site in three pieces, the centre piece weighing 16 tons and being long enough to span between two rows of piles that had been fixed intermediately in the span and placed to leave a waterway of 68ft. A barge was used to bring the rib to the site, and at about high water the barge was swung across between the two stages and the centre length of rib was lifted out of the barge by two cranes and thus placed in position The two end pieces of the rib, each weighing 11 tons, were then lifted out by a single crane and placed at each end of the centre length. There were two joints to be riveted on site.

Twenty-five minutes were occupied in the lifting of the rib at the beginning, but later fifteen minutes were found to be sufficient for the purpose.

Niagara Suspension Bridge.

This bridge carried the North Western Railway of Canada over the Niagara river, and the line is the connecting bridge between Canada and the State of New York.

The bridge first came into use in 1855 as a railway bridge, and it was then found that the lower floor, which had been used as a carriage road, did not assist the top chord to the extent expected by the designer, Roebling, and that in fact the upper chords had been overstrained, whilst the lower members had been working loose at various joints, with the result that decay had begun.

To prevent this defect growing worse, auxiliary chords of timber were added to the old lower chords and firmly bolted to the underside of the floor, but with the result of adding more dead load to the structure.

In 1877 the anchorage chains were strengthened and the method adopted to ensure the correct stress being given to the new chains is interesting.

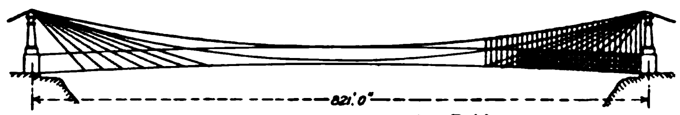


Fig. 29.—Niagara Suspension Bridge.

Each of the bars in the new work was subjected to the stress it was designed to take and the extension carefully noted. The same elongation was given to the bar when it was erected. The new links were expanded by applied heat, and as they lengthened the old chain was brought up to a level so arranged that when the applied heat was removed and the material cooled down, it should bear its proper share of the stress and relieve the old chain of a portion of its load. In the case of other bars of the structure the same result was obtained by the screwing down of the nuts of certain bolts until the desired strain upon the new work was obtained.

In 1880 the trusses were renewed in iron, the work being begun from the centre and carried piece by piece until the ends of the span were reached. The new floor beams were fixed at first by the old ones being taken out one by one as this was done, but the remainder of the new work was fixed in lengths outside the old structure, which was not disturbed until about 150ft. of the new truss in the centre had been placed in position. At this point the old work was removed whilst the new work was fixed, the work of the removal of the old structure being thus about 75ft. to the rear of the work on the new structure. At this time there was practically no change made in the cables.

This bridge has now been superseded by a steel arch bridge of 550ft. span, with a rise of 114ft., which carries a double line of rails 258ft. above the river, and a roadway underneath.

The New East River Bridge.

This is one of the longest suspension bridges in the world, is built between Brooklyn and New York, and spans the East river. The length, including approaches, is 7,200ft., about 1,200ft. longer than the former Brooklyn Bridge. The main span is 1,600ft. in length and the floor is 135ft. above the water at the centre. Accommodation is provided for six railway lines and two roadways, the total width being 118ft.

There are four main cables, each made up of 37 strands of 208 No. 6 steel wires, laid straight, the cylindrical cable finally being about 19ins. in diameter.

The top of the cables where resting on the top of the trestles are mounted on a saddle working on rollers, and having a motion of 3ft. lengthways of the bridge, and during the construction of the bridge the saddles were kept back to their full extent of three feet. The saddles were moved forward gradually during the erection of the main span.

The saddles are 333ft. above the water and the lowest point of the cable is 161ft., leaving a versed sine of 172ft. on the span of 1,600ft., or $\frac{1}{9.3}$ of the span. The cables are anchored 617ft. away horizontally from the piers and at a height of 77ft. above the water.

In the New York and Brooklyn suspension bridge a temporary footwalk had been suspended from two 2⅝ins. wire ropes, but in the case under consideration a more important temporary structure was constructed. Eight continuous footways, four above and four below, were constructed; and these were connected at various points by cross walks or cross bridges, the whole being carried by sixteen wire ropes in four groups of three ropes each, and a single rope suspended above each group. The four upper footwalks are just below the line occupied by the strands of the main cable during spinning, and the four lower walks are just below the line of the permanent cable. The ropes are 2¼ins. in diameter, and are made of seven strands of galvanised steel wires twisted together.

An adjustment, permitting of a movement of four feet, was placed in each of the temporary cables about 100ft. from its end, sockets with screw rods being used for the purpose.

Very careful calculations had to be made so that the finished structure should hang from the temporary structure in the required position after the weight was placed on the temporary cables, and as temperature plays an important part in the position of a cable of such a length it was necessary to make due allowances for temperature changes.

The temporary bridge cables were brought to the site on a large tug on a reel 7ft. in diameter; each rope being 3,020ft. in length and weighing about 14 tons. After the ropes were hauled across the river and hoisted upon the towers the timber work of the platforms was commenced at each tower and worked downward towards the centre of the span and the anchorages. Travellers were arranged to run in two cables with grooved wheels, the platform being large enough to carry four or five men.

When the wires had been laid in the main cables, the upper deck of the footbridge was removed and the floor transferred to the lower deck, and the work of putting on the cable bands and covering was completed from this level.

(To be concluded.)

Power Reversing Gear; Great Eastern Railway.

We are indebted to Mr. S. Dewar Holden, locomotive, carriage and wagon superintendent of the Great Eastern R., for the annexed drawings of the power reversing gear which was designed by Mr. James Holden, and with which several of the Great Eastern locomotives are fitted. It will be seen that the necessary power is supplied by the Westinghouse brake pump without in any way interfering with its most important work, viz., that of creating the power for operating the continuous automatic brake.

A locomotive fitted with this gear can be reversed in the usual way by means of the hand wheel A, or it can be reversed by compressed air, the gear for this purpose being operated by the handle B.

Either of these methods can be utilised at will, as the act of using one system of reversing automatically renders the other system inoperative.

The reversing shaft C is connected to the reversing rod D by the arm E and to the piston rod F by the arm G, a guide H being provided for the end of the piston rod.

To operate gear by hand in the usual way the wheel A and the screw I are rotated; the half nut J and with it the reversing rod D and the arm E are moved one way or the other, the air (compressed or otherwise) in the cylinder K being displaced through the valve L in a maner hereinafter described.

To operate gear by power the handle B is moved one way or the other according to whether engine is required to be put in fore or back gear.

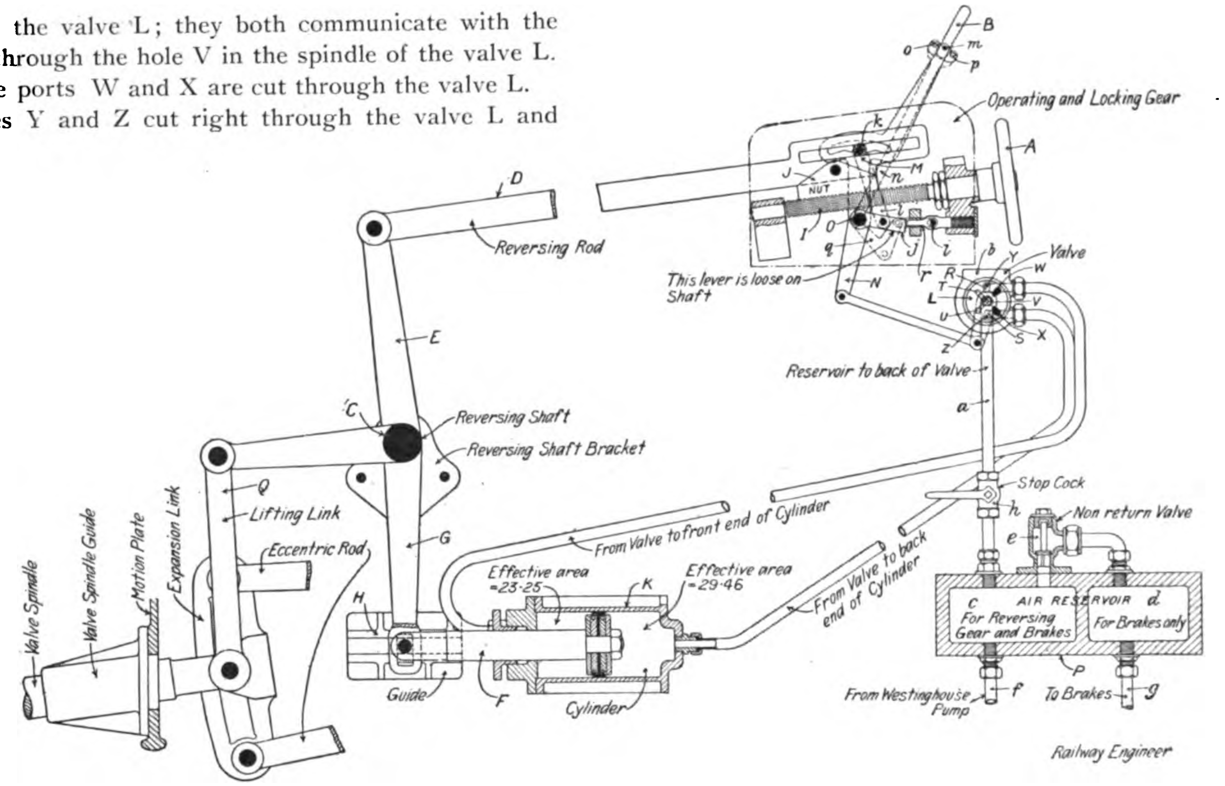
Whichever way handle is moved the cam M attached to it lifts the half nut J out of gear with the screw I, at the same time the arm N, which is also attached to the handle B by the shaft O causes the valve L to rotate, thereby opening one end of reversing the cylinder K to pressure and the other end to exhaust. It should be noted that the half nut J is quite clear of the screw I before this opening of the cylinder K to pressure and exhaust takes place.

In the running position both ends of the cylinder K are in communication with the main air reservoir P through the valve L, the piston rod F being made of such a diameter that the reduced piston area exposed to pressure on the piston rod side of the piston balances the weight of the motion hanging on the lifting links Q.

The valve L rotates on a seating having two ports, R and S, the port R being in communication with the front end of the cylinder K and the port S being in communication with the back end of the cylinder. The exhaust ports T and

U are cut in the valve L; they both communicate with the atmosphere through the hole V in the spindle of the valve L. The pressure ports W and X are cut through the valve L.

Two holes Y and Z cut right through the valve L and



Power Reversing Gear; Great Eastern Railway.

serve the purpose, when gear is in running position (as illustrated), of placing both ends of the cylinder K in communication with each other through the ports R and S and with the air reservoir P through the pipe *a*, which enters the body of the casting *b* at the back of the valve L, viz., on the opposite side of the valve L to that where the ports R and S are.

The air reservoir P is divided into two parts, *c* and *d*, which communicate with each other through the non-return valve *e*.

Air is supplied from the Westinghouse brake pump through the pipe *f* to part, *c*, of the reservoir, then through the valve *e* to part *d*. The brakes are in communication with the pipe *g*, consequently they can draw air from both part *d* and also from part *c* through the non-return valve (a considerable quantity of air being required to release the brakes, etc., on a long train). Air for use with the reversing gear is drawn from part *c* only; the valve *e* prevents any air being taken from the side *d* for this purpose; all chance of the unintentional operation of the brakes due to a reduction of pressure in the reservoir is thus avoided.

The stop cock *h* shuts air from reversing gear altogether should it be at any time necessary to do so.

To prevent the possibilities of half nut J jumping the screw I a locking gear is provided; the pawl *i* engages the lever *j*, which is loose on the shaft O and connected to the pin *k* by the link *l*.

When handle B is moved either way it rotates slightly on the pin *m* before moving the cam M and lifts link *n* by means of one of the pins *o* or *p*, according to which way handle B is moved; the link *n* in its turn rotates bell crank lever *q*, and thereby, by means of link *r*, throws pawl *i* out of gear.

Predetermination of Train-Resistance.*

THE first section deals with the form of the resistance-equation. The different elements of train-resistance are considered, namely, journal-friction, rolling-friction, track-resistance, flange-action, and air-resistance. Each element of resistance is given in terms of the known variables, and existing experimental results bearing on the question are reviewed. The conclusion is arrived at that the component parts of train-resistance may be divided into three groups distinguished by their relation to the speed. The resistances in Group 1 are independent of the speed, and include journal-friction, rolling-friction, and track resistance. Group 2 includes the resistance caused by flange-action, which varies as the first power of the speed. Group 3 includes all forms of air-resistance, which vary as the square of the speed. The resistance-equation is thus shown to be of the form $R = A + Bv + Cv^2$.

The second section is devoted to the determination of the constants in the resistance-equation. The different methods of making train-resistance tests, and the errors to which they are liable, are considered. For the purpose of determining the constants the Author selects the tests made by Mr. Barbier on the Northern Railway of France, as being the most complete and reliable tests of which full records have been kept. These tests were made on two classes of rolling stock, namely, four-wheel and bogie coaches, and a comparison of the results in the two cases, as represented by curves which are reproduced in the Paper, furnishes a means of arriving at the constants in the resistance-equation. These constants depend upon the type of rolling stock under test, and formulas are deduced by which the constants for any given type of rolling stock may be obtained.

In the third section the resistance-formulas are applied to a number of different cases in order to ascertain how far they afford a correct predetermination of the resistance of trains made up of rolling stock entirely different from that tested on the Northern Railway of France. For this purpose a number of the most reliable tests available are selected, the resistance is computed by the aid of the formulas, and

*Abstract of a paper by Mr. C. A. Carus-Wilson, M.A., read before the Institute of Civil Engineers, December, 1907,

the resistance-curve is then obtained and compared with the results of each test. The tests considered are the following:

(1) Tests of bogie-coaches on the Lancashire and Yorkshire Railway.—These coaches differ materially from those tested by Mr. Barbier. The curve obtained by the application of the formulas shows a close agreement with the test results, the mean difference at eight selected speeds from 10 to 80 miles per hour being 3 per cent.

(2) Tests of four-wheel goods wagons on the London and North Western Railway.—Here the calculated resistance is 5 per cent. below that obtained by test.

(3) Tests on eight-wheel bogie goods wagons on the New York, Ontario and Western Railway.—The calculated value is 8½ per cent. less than the observed value.

(4) Tests of eight-wheel electric motor-coaches made by the St. Louis Electric Railway Test Commission.—The resistance obtained from the formulas shows a close agreement with that obtained in the test.

(5) Tests of twelve-wheel high-speed bogie-coaches at Zossen.—The calculated resistance differs from the test value by a constant amount of 100 pounds, being a difference of 7½ per cent. at 60 miles per hour.

In the fourth section the following practical questions are discussed in the light of the conclusions arrived at:—

(1) *Journal-friction in its relation to train-resistance and its possible reduction by roller bearings.*—The real value of roller bearings in railway traction is shown to lie in the reduction of running-resistance and consequent saving of energy, and not in the reduction of starting-effort. The results of tests with roller-bearings on the Eastern Bengal State Railway are given, the saving actually obtained being 1 per cent. greater than that calculated by the use of the resistance-formulas.

(2) *The influence of the truck on the resistance of bogie-coaches.*—The resistance of a coach is shown to depend largely upon the wheel-base of the truck, and the relation of the weight of the bogie-trucks to that of the whole coach.

(3) *The effect of electrical driving on the resistance of bogie-coaches.*—The weight of the motors and the extra weight of the motor-trucks in electrically driven coaches increases the flange action and the total resistance of such coaches. The resistance of electrical motor-coaches is in some cases as much as 54 per cent. greater than that of trailing coaches running at the same speed under similar conditions.

(4) *The reduction of the resistance of goods wagons by the use of bogies.*—The influence of the bogie on train-resistance is shown to be greatest in the case of goods wagons.

(5) *The relation between the tractive efforts required to haul loaded and empty bogie goods wagons.*—Since flange-action depends upon the ratio of the weight of the bogie to that of the whole wagon, it must follow that the resistance per ton of a loaded bogie-wagon must be less than that of the same wagon empty. This is a matter of general experience, and can only be explained on the above hypothesis. The results of tests are given in which a train of bogie wagons was hauled over a considerable distance backwards and forwards, first loaded and then empty. The ratio of the mean drawbar-pull in the two cases was 0·56. When the resistances are calculated by the formulas, the ratio is found to be 0·62.

(6) *The incidence of train-resistance on flange- and rail-wear.*—The energy expended in overcoming flange-resistance is represented by the wear of tires and rails. Tables are given to show how much greater this wearing action is in some cases than in others.

(7) *The reduction of flange-action by mechanical contrivance.*—It is shown that by giving the bogie a lead, as is done in Timmis's bogie-lead, the flange-action of the bogie can be reduced, and that the saving depends upon the ratio of the bogie wheel-base to the distance between the bogie centres, and also upon the ratio of the bogie weight to the total weight.

(8) *The effect of side play on train-resistance, and its possible limitation.*—The amount of play between the flanges and the rails is an important factor in train-resistance. The want of uniformity in current railway practice in this matter is illustrated by a table giving the amount of side play adopted on thirteen different railways in Great Britain, in the United States, and on the Continent. The increased resistance and wear occasioned by large flange-play suggests the importance of a reduction of the play to a standard ⅜ inch as on the London and South Western and other railways.

(9) *The relative importance of air-resistance.*—The resistance of the air with a train of bogie-coaches, running at 60 miles per hour, amounts to about one-half of the total tractive effort required to haul the train. The experiments conducted by the St. Louis Electric Railway Test Commission show that a large reduction can be made in the front and rear air-resistance by shaping the ends, and that by this means a saving can be effected of 10 per cent. of the total tractive effort with a long passenger-train, and 30 per cent. with a single coach.

Locomotive Journals and Bearings.—II.*

Caledonian Railway (continued).

Driving Axle-Box, fig. 9.—This box is made of gun-metal, and is especially notable on account of the diameter of the journal, viz., 9¼in. The box has a width of 16in. between the horns, a height above the centre line of 9⅝in., and wearing surfaces for the horns 20¼in. by 5$\frac{5}{16}$in., the flanges being

*No. I. appeared in February, 1908.

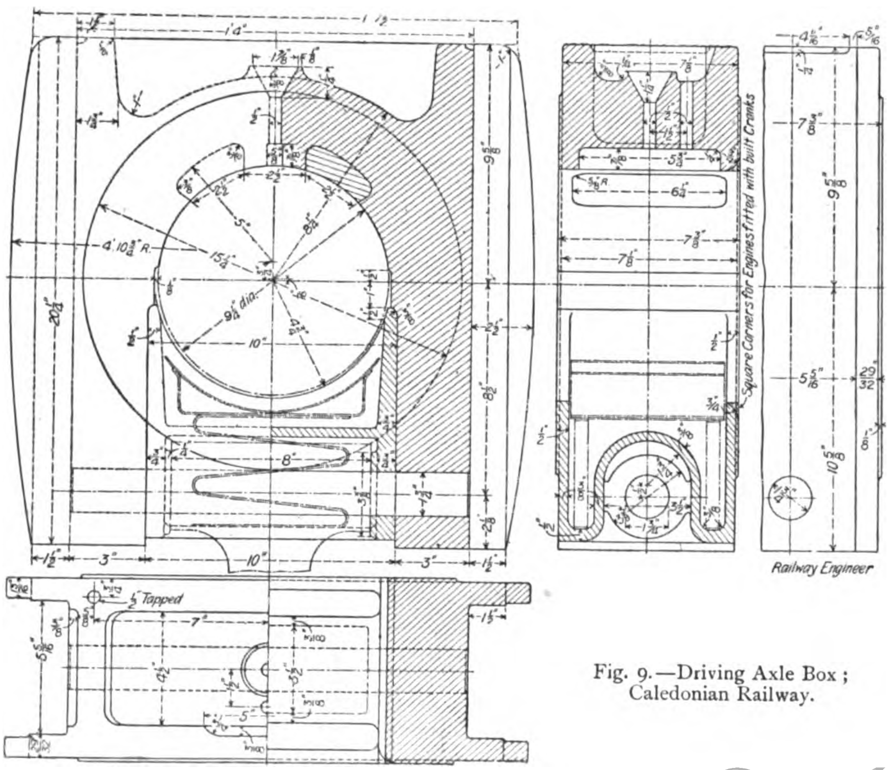


Fig. 9.—Driving Axle Box; Caledonian Railway.

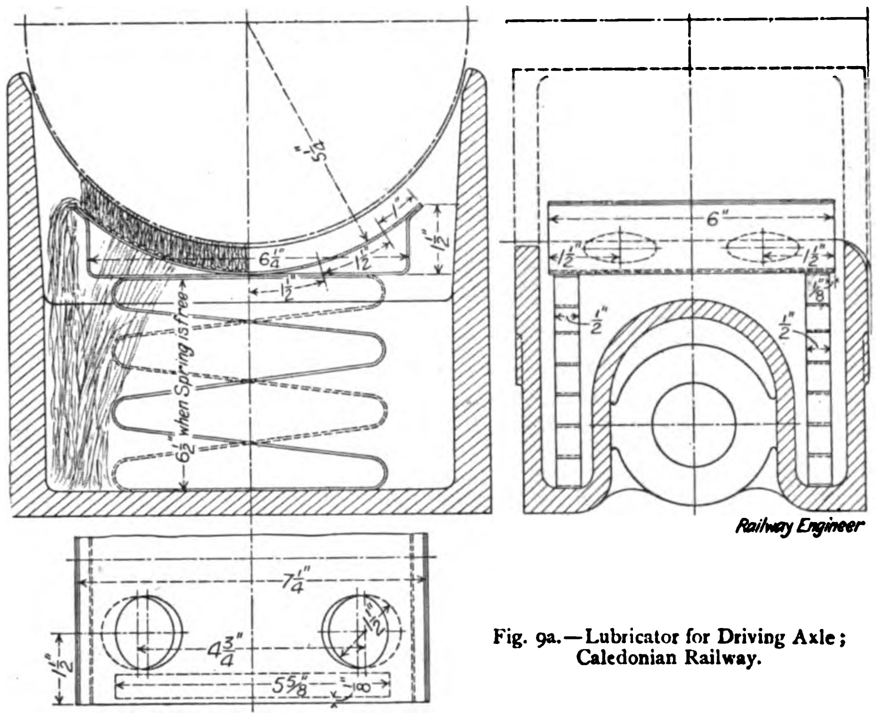


Fig. 9a.—Lubricator for Driving Axle; Caledonian Railway.

1½in. wide. The dead weight carried on the bearing is about 7 tons.

The Sponge-Box or Keep is made of cast-iron, and is supported by the spring-link pin (steel), which is 1¾in. diam.

The Bearing is 9¼in. diam. by 7⅜in., and has two white metal insets 2½in. by 6¼in. It is cased away to a depth of ⅛in. at the sides to a height of ½in. above the centre line.

The crown of the box forms a large oil well, and from this two ½in. feed holes lead to an oil channel ⅝ by 5¾ by ⅞ deep, as shown on the drawing. The central feed hole has a large conical head, into which the oil from the lubricator on the inside of frame drips.

The bottom of the journal is lubricated by a pad, fig. 9a, which is pressed against it by two broad E-shaped flat-steel springs ½in. wide resting on the bottom of the keep.

The top of the box is covered by an iron plate ⅛in. thick.

London and North Western Railway.

The work regularly performed by the express engines of the L. and North Western R. is of an onerous character. Generally speaking, the trains they haul are the heaviest in the country, and the heaviest of them have to be taken over Shap Summit before they make the descent into Carlisle. The longest regular non-stop runs are between Euston and Edge Hill, Liverpool (192¼ miles), and there also are whole services of non-stop trains between Euston and Birmingham, Manchester, Liverpool, and Crewe. The 2-hour express service between Birmingham and Euston is largely run at a speed of 60 miles an hour and upwards; we have on numerous occasions—particularly with the 5 p.m. ex Birmingham—made the journey from Rugby to Euston in 80 minutes. The fastest regular run is between Willesden and Coventry —the 9.20 a.m. Euston to Birmingham. It is true that the North Western engines are not called on to break records or to make spurts to make up time, but that is because when the management advertise a non-stop express the train does not, except very rarely, stop on the journey, and the trains keep remarkably good time. The suburban morning and evening express "business" trains are by no means easy work for the tank engines, and the timing of the Manchester and Liverpool express service involves running 30 miles (start to stop) in 35 minutes.

The details designed by Mr. G. Whale, M.Inst.C.E., chief mechanical engineer, illustrated herewith, are practically standard for several classes of engines, amongst which may be mentioned the 6ft. 6in. 4-coupled "Precursor," the 6ft. 0in. 6-coupled "Experiment," the 6ft. 0in. 4-coupled side tank, and the 5ft. 0in. 6-coupled express goods engines.

The cylinders (inside) range up to 19in. diam. by 26in. stroke, and the working boiler pressure up to 185lbs. per sq. in. The maximum weight allowed on the L. and North Western R. on the rails for any one pair of locomotive wheels is 20 tons, and as the wheels and axle weigh about 4 tons the actual dead weight on each axle box is about 8 tons.

Driving Axle-Box, fig. 10.—This is of cast-steel, with a bronze ("X" metal) bearing. It is 11⅜in. wide and 8in. high above centre. The bottom of the box is closed by a cast-iron keep. The T-headed spring-link and its pin are of forged steel. The bearing is 8in. diam. by 9in. long, and is carried ¾in. below the centre line on either side as shown. Its thickness at the crown is 1⅝in. It is fitted into the cast-steel box and secured by two gun-metal tapered plugs put through on the centre line and riveted over at the bottom of the deep oil channel, which extends along the crown of the bearing. These plugs are pierced with a ⅜in. hole, through which a mixture of tallow and oil, placed on the top of the box, is syphoned by means of worsted trimming to the bearing should the box become heated above the normal and so liquefy the oil and tallow.

The bearing, when running, is lubricated from the footplate, where the supply is at all times under the eye and

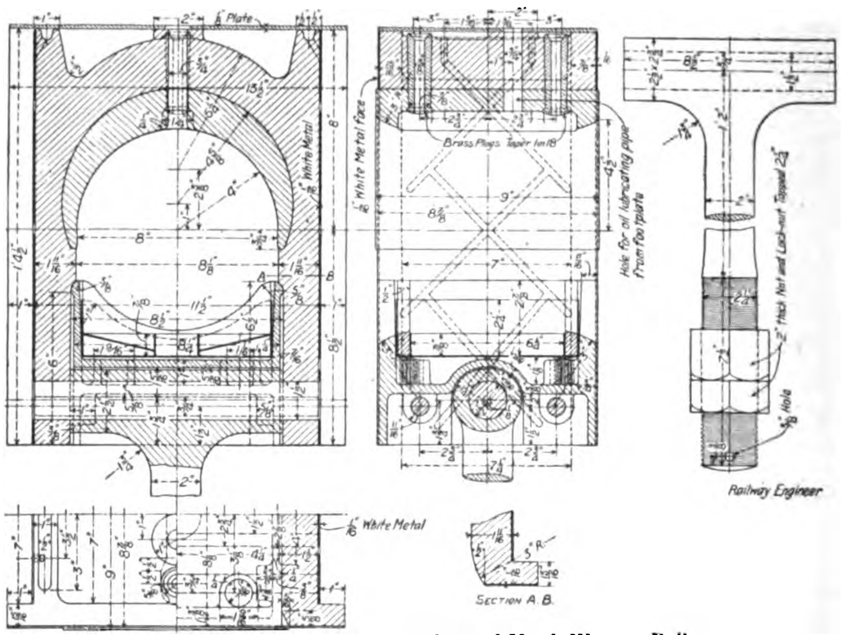
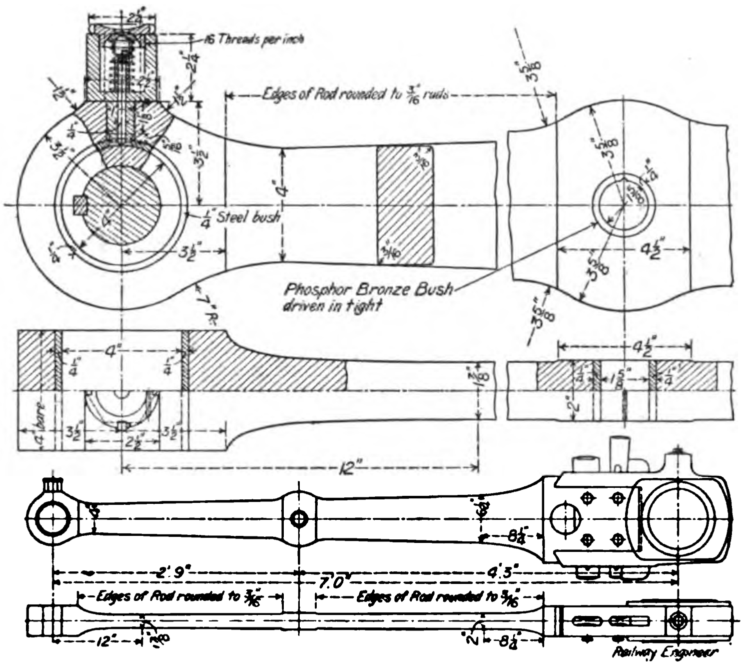


Fig. 10.—Driving Axle Box; London and North Western Railway.

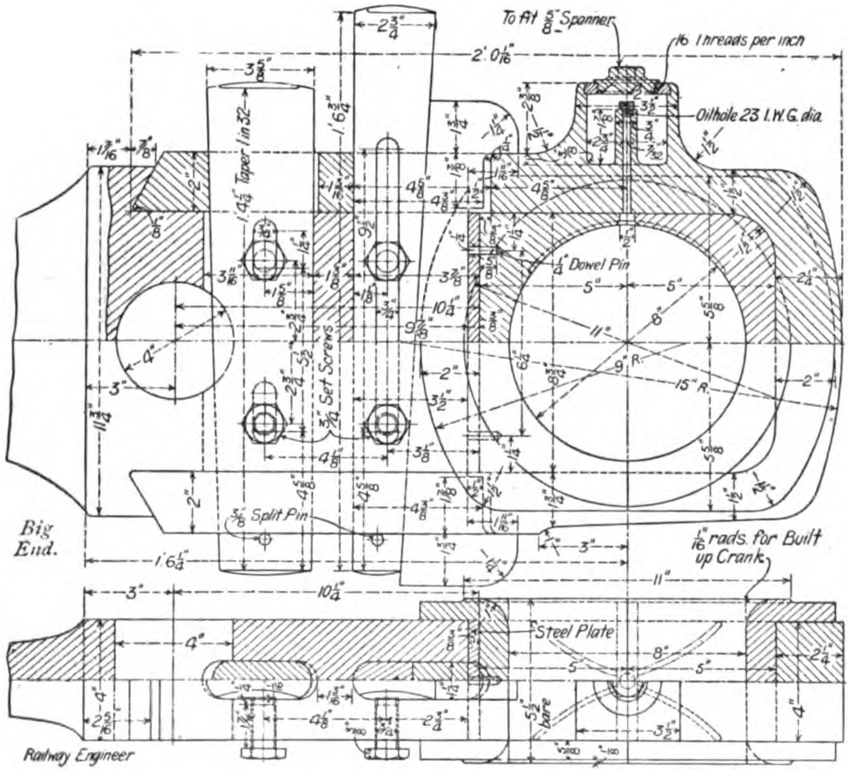
control of the driver, and the pipe conveying it enters the bearing through the ¾in. hole in the crown shown on the drawing.

The sides of the axle-box, 16½in. by 7in., against the horn plates are covered with white-metal $\frac{1}{16}$in. thick; the oil ways for lubricating them (shown on the drawing) lead out of two troughs on the top of the box, and which are covered by the ⅜in. wrought-iron top plate.

The cast-iron Keep is supported in its place between the sides of the box on two ¾in. steel pins, which are a driving fit in the holes, and it supports on its upper surface four spiral springs which carry a light wrought-iron tray with wooden ends which bear on the journal, and thus the surplus oil is caught in the tray and the dust excluded.



Small End.



Big End.

Fig. 11.—Connecting Rod; London and North Western Railway.

Connecting Rod, fig. 11.—This is made of forged steel. It is 7ft. long between the centres. It is rectangular in shape, and tapers from about 4in. by 1⅞in. at the small-end to 6¼in. by 2in. at the big-end, the corners being rounded off to a $\frac{3}{16}$in. radius. The small-end is solid and the large strapped. The rod has a middle bearing 1⅝in. diam. by 2in. for the driving links of the Joy valve gear. This bearing consists of a phosphor-bronze bush ¼in. thick driven in tight.

The Big-End bearing is 8in. diam. by 5½in. bare. It is like the driving-axle bearing, made of a special bronze ("X" metal), which it is not necessary to line with white metal, and is attached to the butt end of the rod by a steel strap and steel cotters. The bend of the strap has a section of 2¼in. by 4in. In other connecting rods which we have or shall illustrate, the tendency of the strap ends to open is prevented by one or more bolts, but in the North Western rods the ends of the strap is dovetailed into the rod and keyed firmly in position by a fine (1 in 32) tapered cotte- (3$\frac{5}{16}$ by 1¼), which is secured in its place by two ¾in. steel set screws and a ⅝in. split pin. The ends of the gib also prevent the strap opening.

The adjustment of the bearing is provided for a taper gib and a loose liner between the gib and the bearing, to which it is attached by two ¼in. by ⅝in. dowel pins. The gib is secured by two ¾in. steel set screws and a ⅝in. split pin. The end of the rod is lightened by a 4in. hole bored through it.

The lubricator cup, square in section, is cut out of the solid steel and closed by a steel lid which has the sides closed over its bevelled edges. In the centre of the lid a wrought-iron stamped cap is screwed in. Formerly this cap used to have in its centre a filling hole which was closed by a brass button and spring, the feeding hole being closed by a $\frac{5}{16}$ steel plug, through which a small hole was drilled, and in this hole a bent pin was carried. We illustrated this arrangement, known as a "needle lubricator," on p. 40 of our February, 1897, issue. The latest arrangement now used as a standard one is illustrated, and in this (Bang's patent) the feed hole is $\frac{7}{32}$in. diam., and into it is screwed a ¼in. brass cheese-headed screw which is pierced by a hole 23 I.W.G. diam., and through this small hole sufficient oil passes for lubricating the bearing.

The big-end is suitable for the crank pins of either solid or built up driving axles, the only difference being that the radius on the bearing is reduced from 1in. for solid forged cranks to $\frac{1}{16}$in. for built-up cranks.

The Small-End of the rod is a solid eye carrying a steel bush, ¼in. thick, the inside of which forms the bearing, 4in. diam. by 4in. bare long. The steel cross-head gudgeon is taper, 2⅝in. diam. middle section, and on it is keyed a bronze sleeve which forms the journal. The oil cup is cut out of hexagonal steel, and is screwed into the small-end, the stem being sufficiently long to project into the steel bush and thus prevent it from moving. The oil cup is of the needle type referred to above. It has a wrought-iron lid screwed in, the filling hole being closed by a brass button supported on a spring. It is locked

in position by a wire $\frac{1}{8}$in. diam. passed through its seat and the ends bent up as shown on the drawings.

The same *style* of connecting rod, but without the bearing for the Joy valve gear, is used on a large number of L. and N.W.R. engines other than the particular classes above mentioned.

Coupling Rod, fig. 12.—The length of the rod, 10ft. between its centres, is one of its striking features. It is made of mild steel and machined to a flanged or I section. Its depth at the middle is 5in. and at the ends $4\frac{1}{2}$in., the flanges are $2\frac{1}{4}$in. by $1\frac{1}{4}$in. at the middle and $1\frac{5}{8}$in. by 1in. at each end of the rod, with the corners and fillets rounded to $\frac{1}{8}$in. radius, the web having a uniform thickness and depth of $1\frac{1}{8}$in. and $2\frac{1}{2}$in. The eyes are $8\frac{3}{4}$in. diam. by $3\frac{3}{4}$in. wide, and carry bronze bushes $\frac{5}{8}$in. thick, having bearings $4\frac{3}{4}$in. diam. by 4in. long. The lubricators are of the same type as that of the big-end of the connecting rod described above, except that they are loose and are cut out of hexagonal wrought-

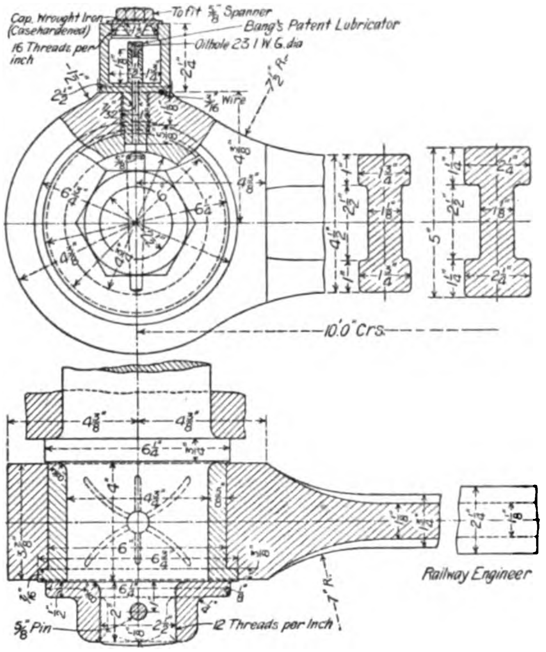


Fig. 12.—Coupling Rod; London and North Western Railway.

iron, and are screwed into the coupling rod ends, the stems being long enough to project into the bushes and thus key them in position. They are fitted with wrought-iron casehardened caps and are locked in position by a $\frac{3}{16}$in. wire put through the seat and its ends bent up. The coupling rods are kept in position by flanged hexagonal nuts screwed—12 threads to the inch—on to the coupling rod pins and locked by a standard peg pin tapered from $\frac{5}{8}$in. to $\frac{7}{16}$in. diam. split at the smaller end.

(*To be continued.*)

Test of Vauclain Superheater, Chicago, Rock Island and Pacific R.R.

The C. Rock Island and P. RR. was amongst the first roads to reduce locomotive boiler pressure in bad water districts, and the results obtained have been so favourable in the reduction of boiler repairs, says the *Railway Age*, that it is proposed to carry still lower pressures and take advantage of superheated steam to prevent the bad effects of foaming due to the use of alkali waters. In the first experiments boiler pressure was reduced from 200 to 175lbs., and more recently tests have been made with a Baldwin consolidation engine having very large cylinders, and equipped with a Vauclain superheater and boiler carrying only 163lbs. working pressure. The tests were made under the direction of T. S. Lloyd, general superintendent motive power, by B. T. Converse, engineer of tests of the Baldwin Locomotive Works, assisted by a representative of the test department of the Rock Island. The superheater used is illustrated in the accompanying engraving. It is substantially similar to that shown by detail drawings on p. 117 of the *Railway Engineer* for April, 1907.

The advantage of a comparatively low degree of superheat was so thoroughly demonstrated that it is worth while to give some particulars with regard to the test and the results obtained. The locomotive is larger and heavier than that which has been in general use on the Rock Island road. The general dimensions and weights are: Cylinders, 28 by 32in.; boiler, 6ft. 8in. diam.; working pressure, 163lbs.; firebox, 6ft. $0\frac{1}{4}$in. by 10ft.; 446 tubes, 2in. diam. and 15ft. 9in. long; heating surface, firebox, 179 sq. ft.; tubes, 3,658 sq. ft.; total, 3,837 sq. ft.; grate area, 60·2 sq. ft.; driving wheels, 5ft. 3in. diam.; weight on drivers, 209,950lbs. on front truck, 26,900lbs.; total weight of engine, 236,850lbs.; total weight of engine and tender, 400,000lbs.

The tests were conducted in two series, the first between Blue Island and Silvis, on the Illinois division, 158 miles, and the second on the El Paso division, between Dalhart, Tex., and Tucumcari, N.M., a distance of 93·5 miles. The moisture in the steam was obtained by a Carpenter separating calorimeter in the Illinois division series and by a Peabody throttling calorimeter in the Texas series. The calorimeter in each case was connected to the turret in the cab, thereby getting steam from the dome of the same quality as in the dry pipe. The speed was obtained by a revolution counter, and readings were taken 30 seconds apart every 10 minutes on the first trip and every 5 minutes on the second run. The amount of coal burned was obtained by keeping an accurate record of the number of shovelfuls put in the firebox. The average weight of one shovelful was obtained by having the fireman fill several times a box placed on scales, using the same shovel he used on the engine. The average weight of the coal in the box was divided by the number of shovelfuls and the quotient was used as the weight of a shovelful. The locomotive was fired up in the shed, and the air pump was kept running at the average rate it ran when standing on a siding with a train. A record was kept of the coal thus burned, so proper deduction could be made for coal burned on the siding.

In measuring the water evaporated the tank was fitted with two gauge glasses, one on the left front corner and one on the right back corner. These glasses had scales behind them divided into inches and quarters, and the capacity of the tank with reference to these gauges was properly calibrated by accurate measurements in gallons. On the run the tank glasses were read at the start, at the tanks before and after taking water, and at the end of the test. A record was kept of the water lost at the engine overflow and the amount of water used in the siding test.

Only one side of the engine was indicated, and the result was taken as one-half the horse-power developed, as the valves had been carefully set and showed the same cut-off on each side. Cards were taken every 10 minutes or 5 minutes, and the revolution counter was read 15 seconds before and after the cards were taken, thus giving the revolutions for 30 seconds. The tonnage hauled was taken from the conductors' waybills or the cars were weighed whenever it was possible. The temperature of steam in the steam chest was taken by drilling a hole through the chest cap and placing a thermometer oil cup through this hole so that the end of the cup would be as near to the steam port as possible. Readings of this thermometer were taken immediately after the card was taken by the indicator. The temperature in front on the front flue sheet and in front of the superheater was taken by means of two pyrometers placed through holes in the smoke-

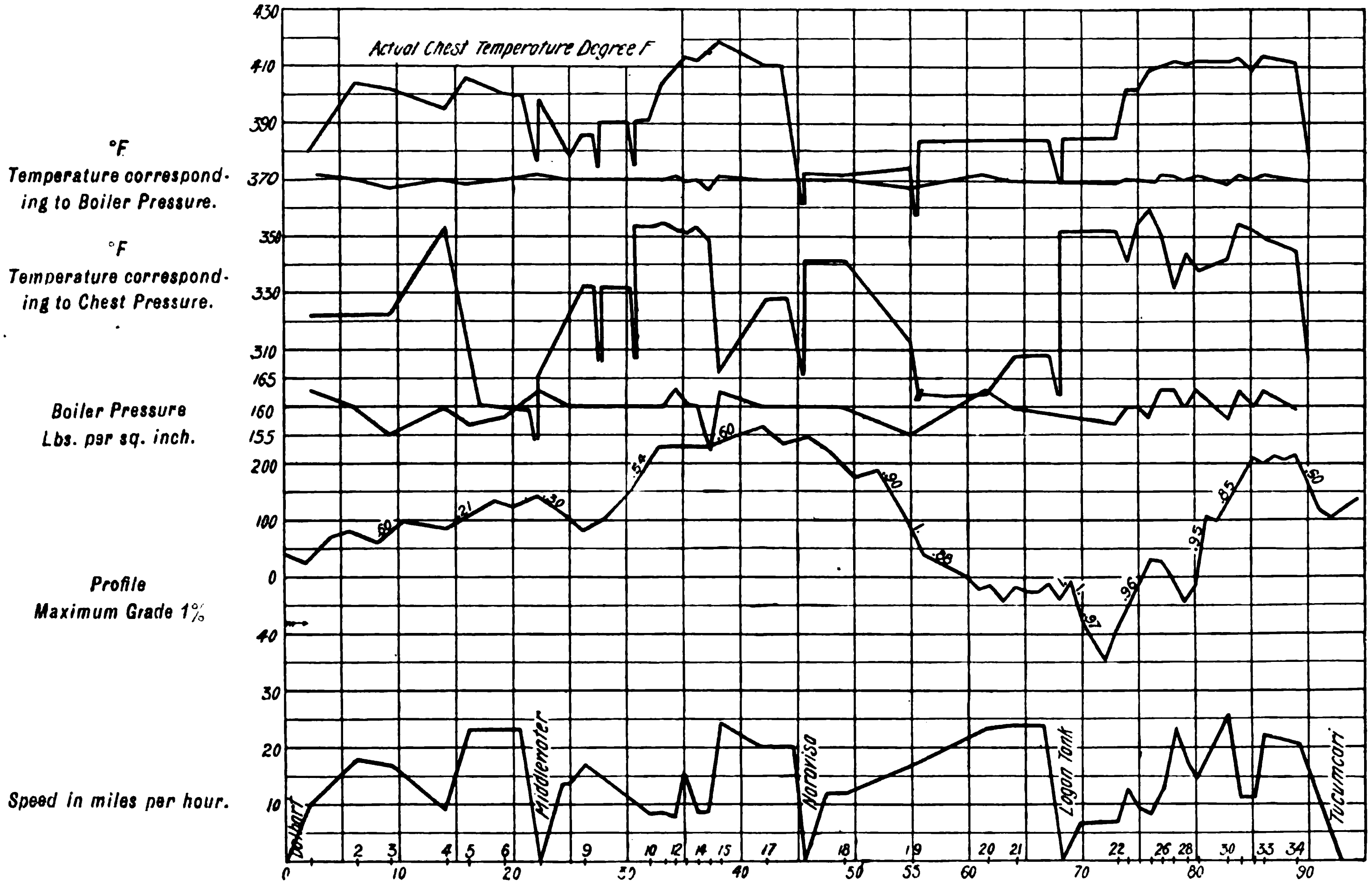
A preliminary run was made on the Illinois division, and

the engine was then returned to the shop and the valves run over and other details adjusted. The testing apparatus was then applied, and three round trips were made on each division, the average results being shown in the accompanying table. During the first two runs on the Illinois division the average temperatures front and back of the superheater were, respectively, 534° F. and 635·1° F. This shows 101·1° F. drop in the temperature of the flue gases while passing through the superheater. On the Illinois division it was necessary to haul trains of such length, to get sufficient tonnage, that trouble was caused by pulling out the draft rigging, but on the El Paso division sufficient tonnage for the engine could be got with a fewer number of cars, and no trouble was experienced with parted trains.

In order to ascertain the loss in temperature between the dry pipe and the steam chest of an ordinary locomotive not taken out of the dome was 1½%.

One of the remarkable results obtained from the superheater engine was the very large increase in hauling capacity. The new engine weighed only 18·4% more than the regular consolidation used on the Rock Island road, but it was able to handle with ease a train 50% heavier over the same road and under the same conditions.

On consolidation engines working on the El Paso, using saturated steam, so much water was carried over to the cylinders that it was necessary to open the cylinder cocks frequently to get rid of it. Trouble is also experienced from blowing of piston rod and valve rod packing after new engines had been in service only three months. With the superheater engine it was only necessary to open the cylinder cocks when starting, and there was no sign of leaky packing. During the entire time of the tests no trouble was experienced



Test of Vauclain Superheater; Chicago, Rock Island and Pacific RR.

fitted with the superheater, an oil thermometer cup was placed in the steam chest in exactly the same manner as on the superheater engine. Readings were taken under conditions as nearly as possible the same as those under which the superheater engine was run. These readings show that the steam averaged about 24° lower in the steam chest than the temperature of saturated steam at boiler pressure, and it was concluded that the superheater under test was responsible not only for raising the temperature of the steam 32·2° F. above the average steam from boiler pressure obtained on the El Paso division, but it prevented the steam from cooling 24° F.; in other words, it added 57·2° F. to the temperature of the steam when it entered the cylinder. This result was obtained when running at an average speed of 15½ miles an hour, and if higher speed had been obtained it is evident from the data given that the degree of superheat would have been decidedly increased. The average moisture in the steam

in lubricating the cylinders of the superheater engine with the ordinary sight feed lubricator.

In the measurements of coal and water it was noticed incidentally that a large increase in consumption attended the hauling of the same tonnage over the same division, due to extra stops and longer time on the road. For example, two runs on the El Paso division, Dalhart to Tucumcari, each train weighing 1,900 tons, one making four stops, the trip occupying 7h. 36min., the other six stops, the trip occupying 9h. 41min., a difference of 2h. 5min. The coal consumption in the former case was 18,172lbs. and in the latter 20,301lbs., a difference of 2,129lbs. of coal, or 11·7% more on the long trip.

The average water used per i.h.p. on the Illinois division was 27·5lbs., and on the El Paso division 22·6lbs. These figures may be compared with the water consumption found in tests made in March, 1906, on the Illinois division of the

Rock Island of a balanced compound locomotive, No. 290, Chicago and Eastern Illinois RR., and a simple engine, No. 1,522, Chicago Rock Island and Pacific RR.

The simple engine used an average of 33·64lbs. of water per indicated horse-power hour, which is 18% more than that used by the superheater engine (in the test here described both engines were running on the Illinois division) and 32% more than that used by the superheater engine on the El Paso division. The compound engine used 29·39lbs. water per i.h.p., or 6·3% more than the superheater on the Illinois division and 23% more than it used on the El Paso division; that is, there was an average saving on both divisions of 31% over the simple engine and 14% over the compound engine, in favour of the superheater.

From the results obtained in the more recent test it was concluded that a locomotive of this type, equipped with a superheater, will show a saving of 15% in the water consumption and 11% in the fuel consumption, over a similar single-expansion engine without superheater. The tables below give the general average of the tests of three round trips each on the Illinois division and on the El Paso division, and an analysis of the coal used under each series of tests is also given. A chart similar to the one here illustrated was made for each test trip, and in this way the various conditions could be easily compared. The lines show for the whole trip: Boiler pressure, actual steam chest temperature, temperatures corresponding to boiler pressure and to steam chest pressure, a profile of the line and the speed in miles per hour. The numbered marks on the bottom line show where the indicator cards were taken. The particular diagram here shown relates to the trip from Dalhart to Tucumcari on August 12th, with 45 loaded cars, 3 empty cars and 1 caboose. The total weight of the train, back of tender, was 1,838 tons. The average superheat on this trip was 31° F. and the average boiler pressure 159·1lbs. The coal burned per square foot of grate per hour was 46·3lbs., and the equivalent water evaporated per lb. of coal 7·89lbs. Referring to the speed curve, it will be noted that this heavy train was rapidly accelerated in starting on grades, though the working pressure was 163lbs.

General Average Results of Tests of Vauclain Superheater.

	Illinois division.	El Paso division.
Number of cars, loaded-light...	45-25	37-2
Train back of tender, tons ...	2,327·0	1,833·4
Number of stops	14·7	3·8
Time for stops, hours-minutes	3;16	1;33
Total time of run, hours-minutes	12;57	6;29
Speed, miles per hour ...	16·1	15·5
Indicated horse-power ...	821·5	891·6
Coal (losses subtracted), lbs....	33,987·0	15,752·6
Coal per i.h.p. per hour, lbs. ...	4·23	3·86
Coal per ton-mile, lbs. ...	0·091	0·119
Water (losses subtracted), lbs.	217,706·3	97,267·7
Water per i.h.p. per hour, lbs.	27·5	22·6
Water per ton-mile, lbs. ...	0·597	0·721
Equivalent evaporation, lbs. ...	7·86	7·54
Superheat (from boiler pressure)	24·63° F.	33·20° F.
Superheat (from initial pressure of cards)	48·8° F.	56·44° F.
Temperature of steam chest ...	386·3° F.	403·6° F.
Boiler pressure, lbs.	154·4	159·8
Tractive effort, lbs.	21,375·0	24,404·7
Length of run, miles	157·0	74·5
Coal per sq. ft. of grate surface per hour, lbs.	57·6	54·9

Coal Analysis.

	Sample taken at—Tucumcari.	Dalhart.
Moisture	0·35	0·27
Volatile matter	37·05	34·86
Fixed carbon	49·96	53·78
Ash	12·04	11·09
Sulphur	0·67	0·57

Warner's Non-Parallel Axle Truck.

The question of rail and wheel wear on most tramway systems has become a serious matter, and various designs of radial trucks have, from time to time, been introduced with the object of overcoming the causes of this abnormal wear.

One of these, known as the "Warner Truck or Steering Control," has been running on the West Ham Corporation Tramways for about two years, and on the 10th January was (by the courtesy of Mr. H. E. Blain, manager of the tramways) shown to a large party of engineers and representatives of the press at Plaistow.

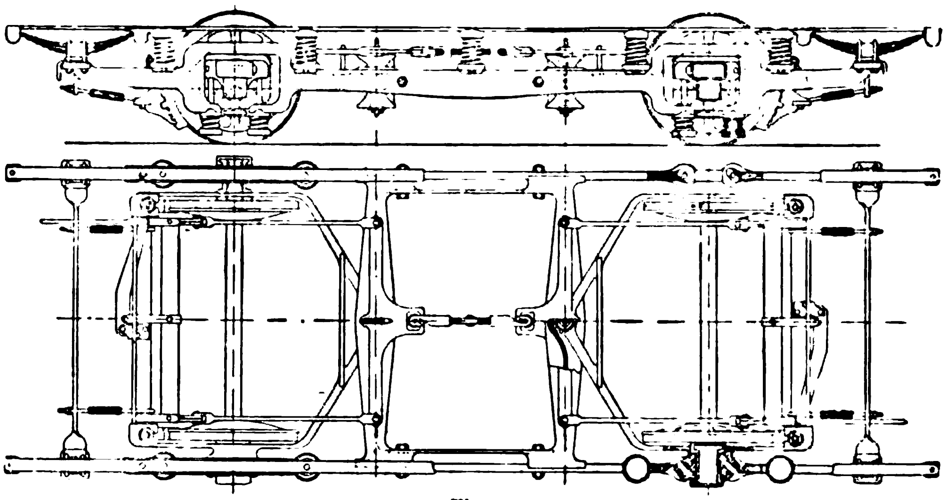


Fig. 1.

The demonstration was quite successful, and to enable the movement of the trucks to be seen the floor of the car was removed. The car was purposely run at the highest speed practicable over a line abounding in sharp and irregular curves, but the ease with which the wheels took the points and curves was most remarkable.

The arrangement of the truck is simple, and consists of the ordinary sub-truck or radial frame with a king pin. From the ends of the axle boxes links are suspended by pins put in at such an angle that the links can and do conform to the radial movements of the sub-truck. The bottom ends of the links are made in a similar manner and coupled to a spring carrier, the lower pins being at the same angle as those above. The bottom of the main frame is slotted to allow the links to swing without restriction like the bolster suspension links on a railway carriage bogie.

Fig. 1 shows the Warner truck, and it may be noted that the king pins do not carry any weight, but are simply used for what Mr. Warner calls central propulsion, all longitudinal stresses between the axles and the vehicle being taken by these pins on the centre line of the car. Two suspension links are shown at each axle box, the axle boxes swinging at a circular angle to the main yokes and making no contact with them whatever.

The steering of the vehicle by the track is applied to the

main truck frame or the carriage-body only after the rolling plane of the wheel has been changed, and the wheel has rolled in the new direction sufficiently to give a considerable inclination of the links. The arrangement is such that it is

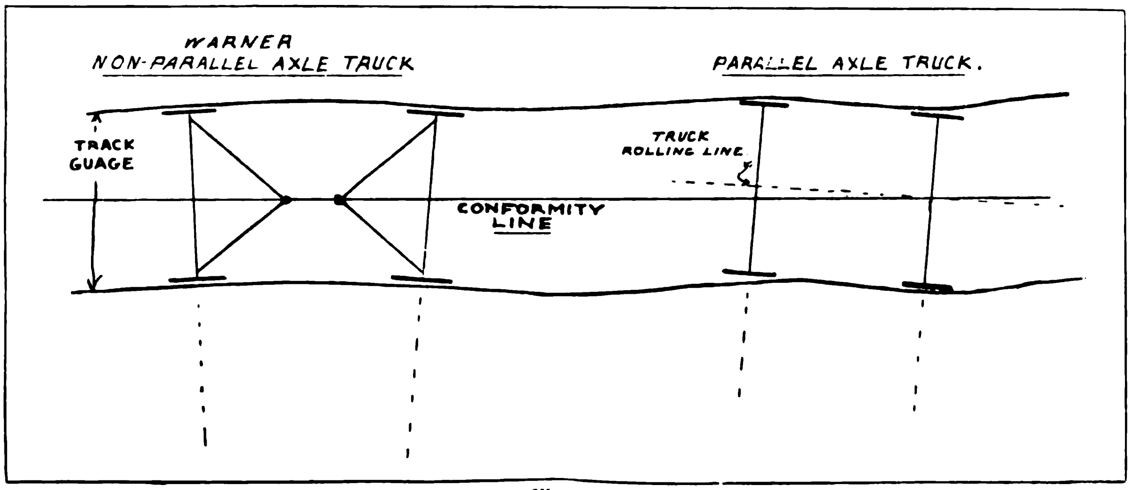


Fig. 2.

possible to obtain an extremely delicate transverse connection between the wheels and the vehicle, and not only are the wheels steered continually, but the body of the carriage may follow a line almost mathematically straight, which Mr. Warner calls the "Conformity Line," and which he defines as "the most perfect path a vehicle running on a given track could follow," as in the sketch, fig. 2. The practical irregularity of the short piece of straight track shown, is exaggerated, to emphasise the difference between the practical straightness of the best track and that of the ideal line, which, if it could be followed, would hardly give any sense of motion to a person riding in the carriage. A parallel axle truck is shown in such a position as to illustrate the well-known difficulty of oscillation with four-wheeled trucks.

Fig. 3. Typical Example of "Warner Lines."

Fig. 3 shows a typical example of "Warner Lines." These lines are a test recording the oscillation of various vehicles, a fine stream of liquid being projected from the front of the car. The photograph shows that three different cars had been tested for the purpose of comparisons. Close measurements can be made between a "Warner Line" and the rails, and thus the side movements of the carriage-body can be ascertained. The lines shown were taken from one end of each car, but had they been taken from the centre they would record with a vertical nozzle, almost the Conformity Line in a horizontal plane. In a vertical plane the Conformity Line is taken at the height of the centre of gravity of a car, and Mr. Warner states that it is parallel to the contour line.

It is claimed that this suspension applied to railway vehicles would render excessive flange pressures and swaying impossible, and thereby greatly reduce draw-bar pull and wheel and rail maintenance, but any further particulars that may be desired can be obtained from Mr. J. S. Warner, Dartmouth Street, Westminster, S.W.

The Locomotive from Cleaning to Driving.—XIV.*

By
JOHN WILLIAMS, *Locomotive Inspector Great Central R.*, and
JAS. T. HODGSON, *Mechanical Superintendent School of Technology, Manchester.*

Lubrication.

The "Boyer" speed indicator, fig. 43, as supplied by Messrs. G. D. Peters and Co., automatically records upon a chart the exact speed at which any point on the road is passed, the number and location of the stops, and the distance, speed and location of any backward movement that may be made.

Moving around a drum in the upper part of the machine is a ribbon of paper, having thereon horizontal and perpendicular lines, each horizontal line from base or zero line representing 5 miles an hour and each perpendicular line a mile post along the road. If the locomotive be moving at the rate of 20 miles an hour the pencil will trace its mark upon the fourth line from the base or zero, and for every mile travelled the paper will move under the pencil ½ inch, or the exact distance from one vertical line to another. A gauge similar in

*Copyright. No. I. of this series appeared in February, 1907; No. II. in March, 1907; No. III. in April, 1907; No. IV. in May, 1907; No. V. in June, 1907; No. VI. in July, 1907; No. VII. in August, 1907; No. VIII. in September, 1907; No. IX. in October, 1907; No. X. in November, 1907; No. XI. in December, 1907; No. XII. in January, 1908; No. XIII. in February, 1908.

appearance to a steam gauge, with a needle pointing to the number of miles per hour at which the locomotive is moving, is fixed inside the cab, in full view of the driver. The chart, fig. 44, is reproduced about one-third actual size and was placed in the recorder when the engine was in the shed. It will be noted from the chart that the shed was about $1\frac{1}{3}$ miles

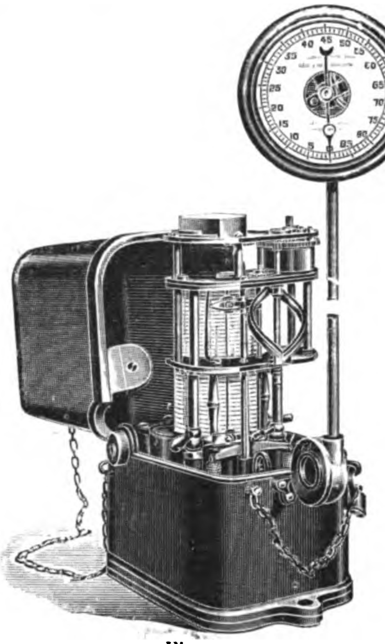


Fig. 43.

from the point at which the train commenced its journey and that the engine made one stop on the way down. After pulling out with the train the first stop was made at a point a little over 2 miles from the commencement of the journey, and a second stop about 11 miles further on; the highest speed attained between the first and second stops being thirty-five miles an hour.

In passing through the different grades from cleaning to driving sufficient time will have elapsed for the driver to have picked up many useful hints with regard to the proper mental heads insist upon the strictest supervision, thus there is a large amount of credit always to be obtained by the economical use of oil, just as there is regarding the consumption of coal. That the wearing surfaces may be damaged by an insufficient supply of oil is incontrovertible, so that the driver may sometimes feel that he is between the hammer and the anvil in attempting to economise on the one hand, with the blame that would result from failures due to heated axles or bearings on the other hand.

The matter, however, is not quite so arbitrary as would appear at first sight, for by the proper attention to trimmings, the viscosity of the oil, the atmospheric conditions, and the removal of trimmings when standing for any length of time, many drops of oil may be saved, which tell their own tale at the end of the month.

Then again, by strict attention to the cleanliness of lubricators, syphons, trimmings, and oil pipes, etc., a steady supply of oil can be ensured, thus keeping the wearing surfaces in far better condition by the steady application of a few drops of oil at the proper time and place than by flushing the surfaces with a larger quantity of the lubricant in an intermittent manner.

The movement or lack of movement in the part to be lubricated determines to a certain extent the method of lubrication; connecting rod ends, eccentric straps, and coupling rods, for instance, where the movement is sufficiently pronounced, are lubricated by the agitation of the oil in the cups when the engine is working, plug trimmings being usually fixed inside the central oil tube so as to regulate the flow to the bearings, as in fig. 45.

Those portions of the engine having no throw are generally lubricated by means of tail trimmings, which syphon the oil from boxes or wells, as in the case of the piston rods, valve spindles, and axle boxes, etc., or from cup lubricators as usually fitted to the top slide bars.

By taking off the syphon tops, where plug trimmings are used, at the end of each journey to see exactly how much oil is in the cups, a driver can soon learn to regulate his trimmings so as to feed just the quantity of oil required.

Much depends upon the manner in which the trimmings are made, for by carefully adjusting the number of the worsted strands to suit climatic conditions or thickness of

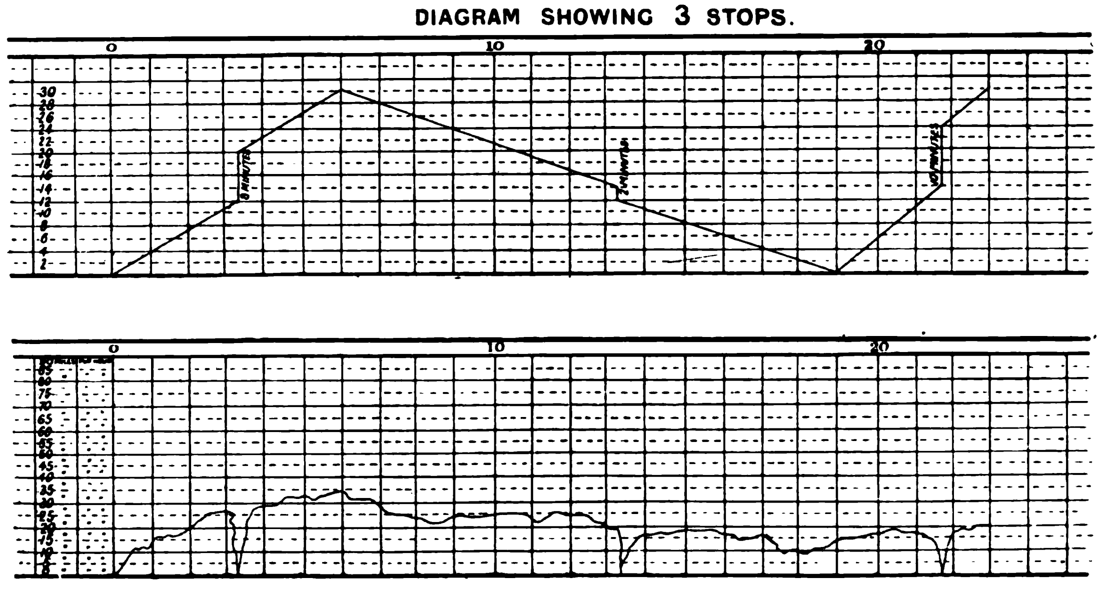


Fig. 44.

application of the lubricants to the wearing surfaces, and in this there is ample scope for the display of that discretion which should guide him in adapting his methods to suit the various circumstances and conditions under which he is expected to run his engine. The oil consumption in the working of a railway is so large and so costly that the depart- oil, etc., a known quantity can constantly be fed so as to give a steady supply to the bearings.

In making a big end trimming, for example, first measure with a piece of wire the distance from the top of the syphon pipe to the bearing, and ascertain at the same time the thickness of the brasses. Assuming that this distance is, say,

6ins., the wire should be twisted for about 4ins. in the middle part, leaving the doubled end for the bottom, and the two ends sufficiently long for bending at the top. Wrap the worsted singly lengthwise over the twisted part of the wire to the required thickness, counting the number of strands so as to know exactly how many will be required when replacing, or for any alteration that may be made necessary by a change in the thickness of the oil supplied from the stores. After wrapping the worsted, twist the ends left for the top so as to leave $\frac{1}{2}$in. of bare twisted wire, which will make the trimming about $5\frac{1}{4}$ins. from the top of the wire to the bottom of the worsted. Bend the ends for the top outward and upward so that the wire will rest upon the top of the tube to prevent the trimming from slipping downwards, and the upright ends will come into contact with the syphon cover, thus preventing the trimming from being thrown upward by the throw of the crank.

Give two neat short turns to the wire below the worsted, so that they will just enter the brasses, so as to conduct the oil to the bearing, and the $\frac{1}{2}$in. piece of bare wire inside the tube at the top will act as a reservoir, allowing the oil to steadily feed its way downward through the worsted to the journal. A small hole is bored through the cap of the syphon and tapped. It is usually plugged with cork, cane or some such porous material, thus allowing the admission of a certain amount of air necessary to permit the feeding of the oil and at the same time preventing the oil being thrown out of the cups by the motion of the rods.

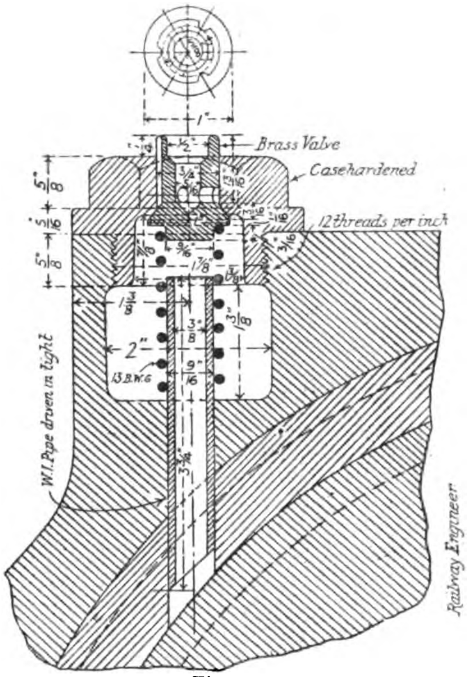


Fig. 45.

The stringing of these corks, although a simple matter, should be done as neatly as possible, thus giving evidence of careful attention on the part of the driver and fireman. The corks are dispensed with in some types of lubricators, the holes in the caps being closed with a button which is held in position by a spiral spring. In this type of syphon the trimming is also sometimes replaced by a bent wire, which projects a short distance down the tube, so that the oil which it retains at every throw of the rod drops from its end down to the journal. This is known as a "needle" lubricator. Another type is Bang's patent, and in this the oil hole is plugged with a screw pierced by a small hole which allows sufficient oil to pass. *(See illustrations on pages 85 and 86 of this issue.)*

The foregoing lubricators are not really syphons, but have been so designated because they are generally referred to as such by drivers and firemen. Lubricators with tail trimmings, however, may be classed as syphons, seeing that the oil is syphoned from the oil-box or well, first upward and then downward from the higher to the lower level by the capillary attraction's action in the trimming. In supplying the oil to the part to be lubricated each worsted strand may be looked upon as a small capillary tube which has a continuous action as long as the oil supply lasts, hence the necessity for removal of trimmings where possible at such times when the supply of oil is not required. The amount of oil that a trimming will convey is therefore varied by the thickness of the oil, the number of strands, or cleanliness of trimming.

The mops which are used in conjunction with tail trimmings for lubricating the valve spindles and piston rods are soon apt to look filthy, so that fairly frequent renewals should be made if only to denote that they are receiving the required attention.

Tail trimmings will also be found on different parts of the motion work. They are so simple that little need be said about their construction, beyond mentioning that for axle-boxes, etc., the twisted wire should be of sufficient length to allow the trimming to just enter the brasses.

Before leaving the shed the driver should examine the engine and bogie axles-boxes to make sure that the oil is in contact with the journals. If water has found its way into the boxes during the washing out, it should be syphoned out, otherwise the oil will float, and only water will be in contact with the journal, which would be liable to heat up owing to the oil supply being cut off. This also applies in a lesser degree to the other lubricators, as by the displacement of a cork or a cover water might be retained, which would interfere with the proper lubrication of the parts affected.

For the lubrication of the piston rings or the valve faces the presence of steam and the temperature of the parts to be lubricated must be taken into consideration, so that the methods adopted are very different to those already quoted for the motion work, etc. Ordinary oils which might be suitable under atmospheric conditions would in most cases be totally unsuited to the high moist temperatures, and would vaporise or entirely lose their lubricating qualities immediately they were introduced into the steam chests or cylinders. The oil mostly adopted is a thick black mineral oil, which has satisfactorily withstood severe tests under high steam pressures and temperatures. Seeing that the piston ring friction is always present when running, the lubrication of the cylinders must be continuous either with the steam pressure in the cylinders, or with steam shut off as when drifting or running down a bank. The Furness lubricator, which is sometimes fitted to either the back or front covers and sometimes to the crown of the cylinders, is most extensively used for supplying oil under the latter conditions. The presence of a vacuum when drifting has already been mentioned in describing the principle of the air valve, and this principle is applied to the Furness lubricator, the suction caused by the pistons being made to lift a small valve, which admits a few drops of oil from the body of the lubricator to the cylinders. The lift of this valve should be as little as possible so that it is returned quickly upon its seat, otherwise the oil will be driven back by the returning piston before the valve has closed. It is maintained upon its seat by the pressure when steam is admitted to the cylinders, so that a little grinding is necessary from time to time, otherwise the steam will leak past, and the resulting condensation will eventually fill the lubricator with water.

Many types of lubricators are made for introducing oil against the pressure, as when steam is present in the cylinders, a common method, that was at one time almost universal for locomotive purposes, being to admit steam into the body of the lubricator, and by the gravity of the resultant water of condensation force the oil into the steam pipe or steam chests. This type is called a displacement lubricator, and the one known as the "Roscoe" fitted to the sides of the smoke-box was perhaps the most extensively used. A small pipe from the main steam pipe in the smoke-box is connected to the upper part of the lubricator, and the water formed by condensation of the steam supply falls by its

specific gravity to the bottom of the oil cup, thus displacing the oil, which is forced outward through the tube to the main steam pipe. It will therefore be evident that a small amount of space should be left above the oil in the cup when refilling, so that room will be provided for the initial condensation to take place before displacement can commence. A drain-cock is fitted to the bottom of the lubricator for draining the water, which should only be tightened up by hand and not with a spanner, as is often the case. If the seating is not already damaged it may be injured by screwing up too tight, and if faulty should be attended to by the shed staff. A small valve regulates the oil supply to the main steam pipe by controlling the steam inlet to the lubricator.

Although ordinary displacemen· lubricators have in times past been extensively used, the difficulty of access for regulating or re-filling during a journey made the introduction of "sight feed" lubricators advantageous from the driver's point of view by giving him a better and more positive control over the oil supply to the steam chests or cylinders.

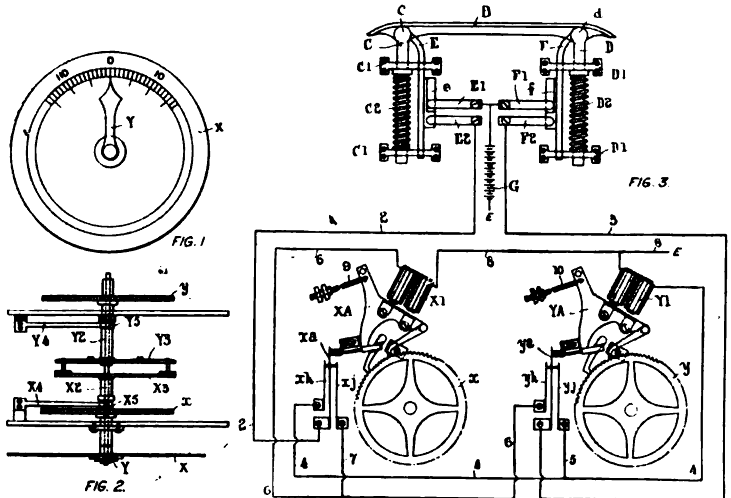
The small pipe passing from the main steam pipe through the smoke-box to the displacement lubricator was also liable to be damaged by the fireman's shovel when cleaning out the smoke-box, or to be gradually burnt away by the hot ashes and eventually burst. When this occurred a bad blow up the chimney would be developed which many times has misled a driver, since a faulty valve may sometimes give a somewhat similar blow.

(To be continued.)

Recent Patents relating to Railways.

THESE abridgements of recently published specifications are specially compiled for this Review by Messrs. Wheatley and Mackenzie, Chartered Patent Agents, 40, Chancery Lane, W.C., from whom copies of the specifications can be obtained at an uniform price of *8d.* each.

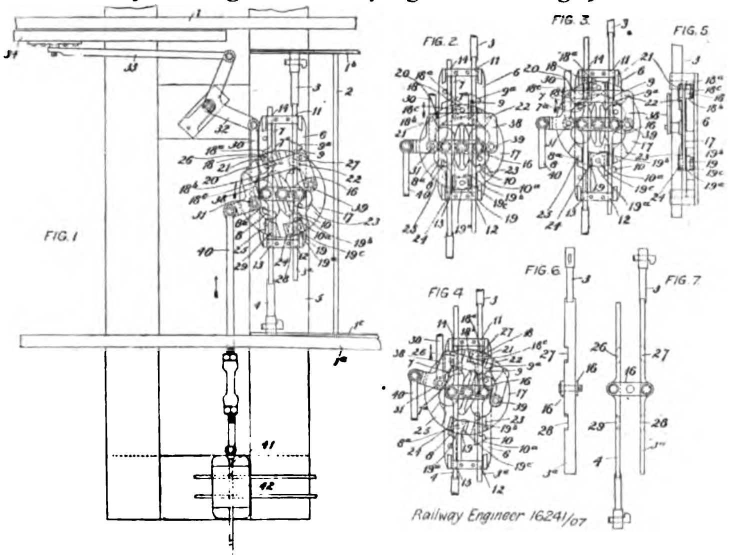
Train Indicating and Controlling Apparatus. *25,712. 14th November, 1906. W. R. Sykes, Jun., "Wyndcott," Birchwood Park Avenue, Swanley, Kent; H. T. W. Reason, 112, Murchison Road, Leyton, Essex; and F. W. Leake, Great Eastern Railway, Liverpool Street Station, London.* This invention consists of an improved method whereby it can be ascertained whether the whole of a train has pasesd over a given point on a railway as at a terminal station, into or out of a siding, and into or out of an ordinary block section, and utilisation of the rail contact or treadle used and an electrical current for the counting of the wheels of a train to also indicate the direction of the train and to utilise that in-



formation for giving selective sound or other signals at a gate level crossing and by means of an electrical counter and indicator to so indicate the number of wheels to control the use of signals that the same signals may not be used until the same number of wheels passes out of the station, siding or block section that entered into it. A deal plate X and index hand Y of a wheel counting and registering apparatus are mounted to revolve about a common axis, and are adapted respectively to rotate as one with the propulsion wheels x and y through which they receive motion from the electro-magnets X^1 and Y^1 respectively. Upon the spindles X^2 and Y^2 which carry the dial plate X and index hand Y, are also mounted contact bars X^3 and Y^3 adapted, when the index hand Y is in the zero position relatively to the dial plate X, to close a circuit between two insulated stationary spring contacts X^4 and Y^4 which bear respectively on contact rings X^5 and Y^5 rotating as one with the dial plate X and index hand Y. The closure of this circuit may be utilised to so control the signals commanding a terminal bay, siding, or block section of the railway that the signals employed to admit a train thereto cannot be used again for a like purpose until the mutual angular displacement of the dial plate X and index hand Y brought about in consequence of the entrance of a train into such bay, siding, or section, has been nullified by the subsequent restoration of the dial plate and index hand to normal or resting position wherein the index hand points to zero on the dial as before. In the arrangement illustrated in fig. 3, which may represent the apparatus as applied to control the signals commanding the entrance to a terminal bay or siding, a single train-operated circuit closer is employed for operating the electro-magnets X^1 and Y^1. The circuit closer comprises a treadle B extending alongside of the permanent way rail and yieldingly supported so that its upper surface is parallel to that of the rail but adapted to be depressed by the flanges of each successive pair of wheels of a train passing over the railway in either direction. For this purpose the treadle B is pivoted at opposite ends, as at c and d, to two vertically slidable rods C and D which are guided in bearings as at C^1 and D^1 and pressed upwards so as to maintain the treadle B at normal level by means of springs C^2 and D^2 which may be coiled about the rods C and D and confined between collars on the rods and fixed abutments as indicated. Pivoted to the opposite ends of the treadle B, preferably at the points c and d, are also two vertically slidable rods E and F which are guided similarly to the rods C and D respectively so as to participate in their movements, the rods E and F carrying insulated contact pieces e and f which, on the treadle B being depressed from one end or the other, close an electric current between pairs of contact springs E^1 E^2 or F^1 F^2. Of these springs E^1 and F^1 are both to earth through a battery G, whilst E^2 and F^2 are connected by wires 2 and 3 with contact springs x^a and y^a whose positions are controlled by those of the armature levers X^A and Y^A of the electro-magnets X^1 and Y^1 respectively. Normally, that is to say so long as the electro-magnet X^1 is not energised, the armature lever X^A holds the spring x^a against a contact x^h and away from a contact x^j, this condition being reversed when the magnet X^1 attracts its armature. Similarly, so long as the magnet Y^1 is not energised, the armature lever Y^A holds the spring y^a against a contact y^h and away from a contact y^j, this condition likewise being reversed when the magnet Y^1 attracts its armature. The contact x^h is connected by wire 4 to one end of the winding of the electro-magnet Y^1, and by the branch wire 5 to the contact y^j; whilst the contact y^h is connected by wire 6 to one end of the winding of the electro-magnet X^1, and by the branch wire 7 to the conact x^j. *(Accepted 14th November, 1907.)*

Point and Signal Apparatus. *16,241. 15th July, 1907. A. G. Kershaw and Saxby and Farmer, Ltd., 53, Victoria Street, Westminster.* Bars 3 and 4 constituting a split stretcher are pivotally connected by links 16 and on the links is pivoted a rotary locking member 17 upon which are formed pieces 18, 19 having respectively convex faces 18^a, 19^a adapted to engage with the concave faces 7^a, 8^a of lugs 7 and 8 on a base casting 6, and concave faces 18^b, 19^b adapted to engage with the convex faces 9^a and 10^a of lugs 9 and 10 on the base casting 6. Attached pivotally to the pieces 18, 19 are rollers 18^c, 19^r which also engage with the faces 7^a, 8^a, 9^a, 10^a of the lugs 7, 8, 9, 10 of the base plate 6. Upon the rotary locking member 17 are also formed locking pieces 20, 21, 22, 23, 24, 25 which

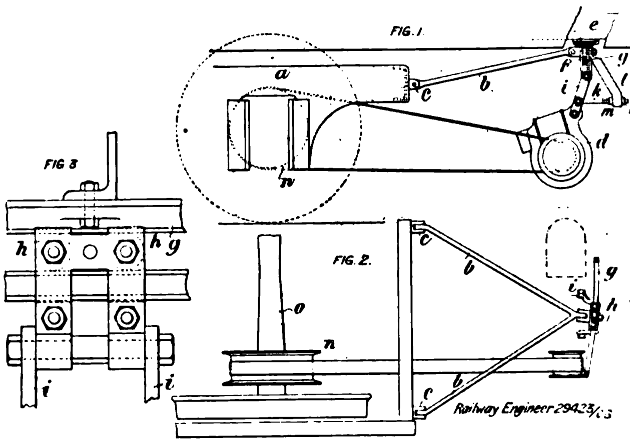
are adapted to engage with notches 26, 27, 28, 29 of the split stretcher or bars 3 and 4. A rod or link 30 is pivotally connected at one end 31 to the rotary locking member 17 and at the other end to a crank 32. The crank 32 is connected by a rod or link 33 to the locking bar 34, and the locking bar 34 is connected to the operating lever. To the rotary locking member 17 a connecting part 38 is attached at 31 and 39. At one extremity of this connecting part 38 is a rod or link 40 which is conected to or forms part of the locking slide 41 of a signal detector 42. Assuming the parts to be in the position shown in fig. 1, a movement given from the signal cabin to the rod 37 is transmitted to the rod or link 30 moving it in the direction of the arrow. The first portion of this movement of the rod 30 will revolve the rotary locking member 17, disengaging the face 18^a of the piece 18 from the face 7^a of the lug 7 and also disengaging the face 19^b of piece 19 from the face 10^a of lug 10, and also withdrawing the locking pieces 21, 25 from the notches 26, 29 of the bar 4 and the locking pieces 22, 24 from the notches 27, 28 of the bar 3, thus unlocking the points. At the same time the revolving of the rotary locking member 17 revolves the connecting part 38 with it and so moves the rod 40 and the interlocking bar or slide 41 of the signal detector 42 thus locking the signal slide or slides which, with the points as set in fig. 1, were free. By the time face 18^a of the piece 18 is clear of the face 7^a of the lug 7 and the face 19^b of the piece 19 is clear of the face 10^a of the lug 10 the piece 18 will abut against the lug 9 and the piece 19 will abut against the lug 8 as shown in fig. 2. Owing to the abutment of the piece 18 of the rotary locking member 17 against the lug 9 and the



piece 19 of the rotary locking member against the lug 8, the rotary locking member 17 can revolve no further, so that the continued movement of the rod 30 in the direction of the arrow will draw the rotary locking member 17 along with it; with the rotary locking member 17 will move the links 16 and the bars 3 and 4, thus moving the switch points 1^b 1^c from the normal position shown in fig. 1 to the reverse position, *i.e.*, with the switch tongue 1^b against the stockrail 1 and the switch tongue 1^c away from the stockrail 1^a. The connecting part 38 is also moved along with the rotary locking member 17 and moves the rod 40 and the interlocking bar or slide 41 of the signal detector 42. This movement of the interlocking bar 41 still keeps the signal slides locked. The final part of the movement of the rod 30 again revolves the rotary locking member 17 and causes the face 18^b of the piece 18 to engage with face 9^a of the lug 9 and the face 19^a of the piece 19 to engage with the face 8^a of the lug 8 and also inserts the locking pieces 20, 24 respectively into the notches 26, 29 of the bar 4 and inserts the locking pieces 21, 23 respectively into the notches 27, 28 of the bar 3, whereby the points are locked in their operated position, the parts of the point operating and locking apparatus being then in the position shown in fig. 4. With this revolving of the rotary locking member 17 the connecting part 38 is also revolved and moves the rod 40 and the interlocking bar 41 of the signal detector 42 and releases the signal slide or slides for the points in their reverse position. *(Accepted 21st November, 1907.)*

Suspending Dynamos for Train Lighting. 29,423. *24th December, 1906. W. R. Preston, of J. Stone and Co., Ltd., Deptford, C. Roe and C. H. Roe, 6, East Mount Road, York.*

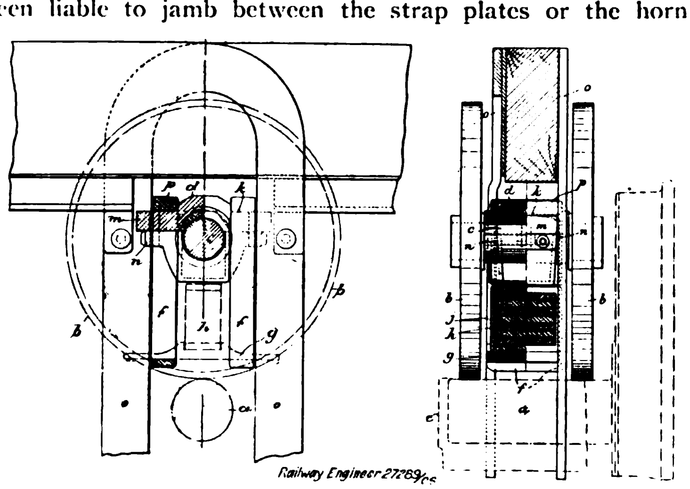
This invention consists in suspending a dynamo, for the electric lighting of trains, from the body of the vehicle in such a manner that the dynamo may follow the lateral movements of the axle from wheih it is driven, so that the driving and driven pulleys shall always be in line and the tension on the belt the same whatever curve or bend the train may pass over. The invention is particularly applicable to bogie coaches or cars, and comprises a frame pivoted at *c* to the bogie truck *a*. The dynamo *d* is connected with the end of the



frame and at the same time supported from the bottom of the underframe *e* by a slide *f* jointed to the frame *b* and adapted to slide on a slotted curved guide *g* the centre of which is struck from the vertical axis or pivot of the bogie truck. The slide is suitably provided with rollers *h* to reduce friction, and the dynamo is hung from links *i* provided with an adjusting screw *k* passing through a bracket *l*, and which by nuts *m m* regulates the tension of the belt. The dynamo is driven as usual from a pulley *n* mounted on one of the axles *o* of the bogie truck by a belt which passes round the pulley. *(Accepted 7th November, 1907.)*

Anti-friction Mechanism for Wagons. 27,289. *30th November, 1906. A. Spencer, 77, Cannon Street, London.*

In anti-friction mechanism wherein large anti-friction wheels are arranged one at each side of the horn plates on a short axle passing through a bearing box, such box has hitherto been liable to jamb between the strap plates or the horn

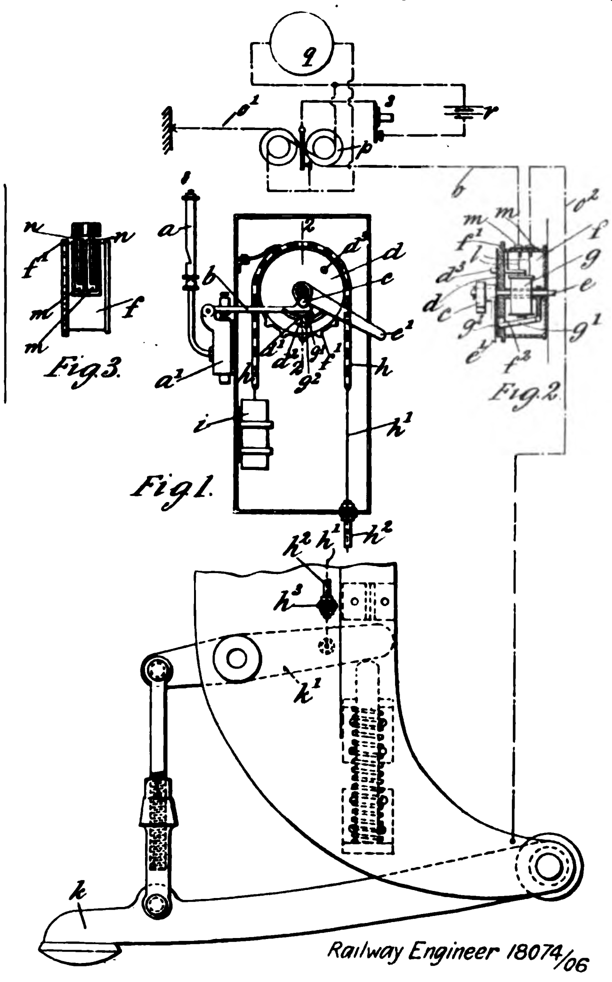


plates, and the present invention is designed to obviate this. For this purpose the bearing box *d* of the axle *c* is arranged to rock between the straps *f*, and between the horn plates *o*.

The upper sides *k* of the lateral flanges *m* of the bearing box *d* are curved and the sides *n* of the flanges *m* taper off in a downward direction, so that whilst at their upper parts the flanges closely fit between the horn plates *o*, at their lower parts such clearance is left at each side between the flanges and the horn plates that the bearing box *d* can rock about the points of contact of the curved upper parts of the flanges with the straight undersides of the top members *p* of the straps, clearance being left between the flanges and the side members of the straps to permit of this movement. *(Accepted 21st November, 1907.)*

Signalling Apparatus. *18,074. 11th August, 1906. C. M. Jacobs, "St. Cuthbert's," Alexandra Road, Reading; R. J. Insell, 17, Russell Street, Reading; and E. A. Bowden, 21, Balfour Avenue, Hanwell, Middlesex.*

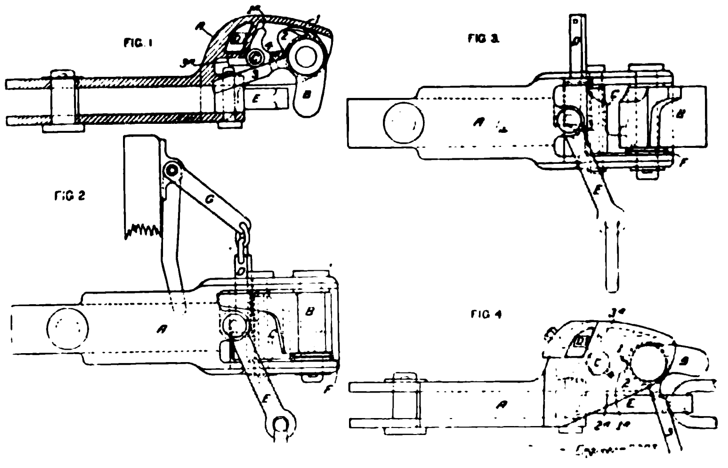
This invention relates to improvements in a signalling installation described in a prior specification, No. 12,661[05], wherein a single ramp on the line at each signalling position raises a lever carried by the train to open a normally closed circuit, thereby causing a danger signal to be operated. According to



the present invention a mechanical device is substituted for the normally closed circuit for operating the danger signal, the restraining of the signal being effected electrically. The whistle *a* is normally kept closed by a lever *b* on an inclined surface of which bears a cam *c* fixed on a disc *d* mounted free to turn on a spindle *e*. Also free to turn on this spindle is a drum *f* within which is fixed so as to turn therewith an electro-magnet *g* with its pivoted armature g^1. The drum carries sprocket teeth f^1 engaging with which is a chain *h* having one end attached to a weight *i* and the other to a steel wire h^1 which extends through a brass tube h^2 and is connected at its other end with the arm k^1 of the lever *k* by means of an insulated washer h^3. The free end g^2 of the armature g^1 extends through a port f^2 in the face of the drum *f* into a slot d^1 in the disc *d*. The terminals of the electro-magnet *g* are connected by leads *l* with insulated contacts *m* on the periphery of the drum *f*. Brushes *n* bear on these contacts, one being connected by lead *o* with one terminal of a winding *p* on a polarised relay, the other end of which winding is connected by lead o^1 with earth, while the other brush *n* is connected by lead o^2 with lever *k* which is mounted in insulated manner on the under-frame of the locomotive. When the locomotive passes over a ramp the lever *k* is raised, whereby the wire h^1 is pulled, weight *i* raised and drum *f* rotated clockwise. In the normal position of the parts the end g^2 of the armature rests in the right hand half of the slot d^1, so that as it turns with the drum it engages with the end d^2 of this part of the slot and causes the disc to turn with the drum. Thus the cam *c* rides off the inclined surface of the lever *b* and the whistle sounds. When the locomotive has passed over the ramp, the lever *k*, wire h^1, weight *i* and drum *f* return to their normal positions. The disc *d*, however, remains in the position into which it has been turned until the engine-driver lifts the lever e^1 which is free to turn on spindle *e*, but engages a stop d^3 on the disc. If the line is clear the signalman turns a switch to close a circuit through a conductor on the ramp, the lever *k*, lead o^2, one contact *m*, the magnet *g*, the other contact *m*, winding *p* and earth. The magnet *g* is thus energised and raises its armature g^1 so that the end g^2 thereof rests in the left hand part of slot d^1. Thus, when the drum *f* is rotated the end g^2 of the armature merely rides in the left hand half of slot d^1 and the disc *d* is not turned so that the whistle remains closed. *(Accepted 11th November, 1907.)*

Couplings (Automatic). *8,383. 10th April, 1907. G H. Eaton, 18, Broxash Road, Clapham Common, London, S.W.*

Each coupling member comprises a head or casing A having pivoted therein between upper and lower jaws a spring pressed tongue B provided with lugs 1, 2, 3 and a locking device C with lugs 1A, 2A, 3A. A chamber is also formed in the casing to receive a vertical key D adapted to be operated from the ride of the vehicle. In the operation of coupling the tongue B being open, its lug 3 comes into contact with the opposing tongue of the fellow coupling, and pivoting the former round upon its pin and increasing the tension upon spring F, fig. 2, until its lug 2 passes through the recess 4 of lock C, and it reaches lug 1A of the latter, which in turn is pivoted upon its centre pin, until its rear lug 3A passes from under the partly rounded base of key D, which it had previously been suspending, and allows it to fall by gravity into the required position against the side of lug 3A of lock C, while at the same moment the opposite lug 2A of C comes into contact with the opposite side of lug 2 of tongue B, fig. 1, and firmly locks the coupling, after making a connection with a fellow automatic coupling, from the fact of C, pivoting upon a centre pin, and the lines of force being in reverse direction at opposite ends, combined with fact of the pivot pins of B and C being on lines parallel to the centre



line of the vehicle. Should both the automatic couplings be in the unlocked or open position upon meeting to make a joint connection, their lugs 3, fig. 4, being sufficiently extended for that purpose, each one simultaneously strikes the nose of the opposing tongue B, and pivot both round on their

pins at the same time, when the same respective movements with the locks C and keys D in each coupling is effected as that described. The reverse or unlocking position of the automatic coupling is effected from the side, by means of lever G, or a chain being used to withdraw key D from the locking position at the side of lug 3A of lock C, fig. 1, when the tension on the spiral spring F, attached to and round the base of the tongue B, causes the latter to fly open until reaching the wall of the case, and remains there, at the same time its lug 2, being in contact with lug 2A of C, fig. 1, pivots the latter partly round upon its centre pin until lug 1 of B comes into contact with lug 1A of C, and continues the circular movement of C until its rear lug 3A passes under and holds suspended the key D until another connection with a fellow automatic coupling is desired. *(Accepted 28th November, 1907.)*

COMPLETE SPECIFICATIONS ACCEPTED.

A.D. 1906.

17504. Automatic couplings. Shailer and Hogan.
18074. Signalling on railways. Jacobs, Insell and Bowden.
25569. Electric block signals. Finnigan.
25712. Counting apparatus and rail contacts, or treadles operated by railway vehicles for signalling, indicating, and controlling purposes on railways. Sykes, Harry Thomas William Reason, executor of the late Frederick Thomas Hollins and Drake.
25773. Ventilators for railway vehicles, tramcars, and for other purposes. Beresford.
25922. Detonating fog signals for railways. Ludlow.
26369. Construction of monorail locomotives and the like. Penney.
26394. Device for closing and locking and unlocking the doors of railway carriages and the like. Brockwell and Faro.
26477. System of railway fog signals. Kent-Watson and Lettice.
27289. Anti-friction mechanism for railway wagons and other vehicles. Spencer.
28901. Railway signalling and like lamps and lanterns. Hamm.
29158. Railway signalling and communicating apparatus. Brook.
29423. Electric lighting of trains. Preston, Roe and Roe.

A.D. 1907.

73. Construction of monorail wagons and vehicles and the like. Penny.
244. Electrical automatic signalling systems for railways. Sayers.
701. Spark arresters. Notter.
959. Trucks or bogies of railway and tramway vehicles. Panton.
1110. Vehicle and locomotive sanding apparatus. Taylor.
2624. Fog signalling apparatus for use on railways and the like. Clough and Watson.
4150. Railway wagons or vans. Crouch.
4477. Indicating on railway engines what signal is being passed by a train. Kershaw and Cliff.
4477a. Indicating to signal boxes the arrival of trains at a signal and the working of the signal mechanism. Kershaw and Cliff.
4477b. Signalling apparatus for branch roads on railways. Kershaw and Cliff.
4734. Apparatus for cooling vehicles. Inter-colonial Railway Company.
4735. Apparatus for cooling vehicles. Inter-colonial Railway Company.
4867. Axle-boxes for railway and tramway vehicles. Walsh.
5418. Central buffer couplings. Scharfenberg.
5729. Block signal system for railways. Wise.
6050. Sliding windows for railway carriages and other vehicles. Currie.
7109. Railway signalling. Majunke.
7394. Underframe for railway and other cars. Hansen.
7896. Couplings for railway vehicles. Marillier.
8383. Automatic couplings for railway and other purposes. Eaton.
9040. Tramway and railway rails. Metz.
10160. Car couplers. Janney.
11508. Mechanism for controlling the action of railway wagon and other fall-down doors and flaps. Mein.
11189. Couplings for railway and like vehicles. Downing.
14872. Point signal and the like adjusting mechanism for railroads. Doyle.
16171. Apparatus for fastening and unfastening the bottom doors of railway wagons. Pettigrew.
16241. Railway point and signal apparatus. Kershaw and Saxby and Farmer, Limited.
16903. Ventilator suitable for railway carriages and other vehicles and structures. Kite.
16946. Railway trains. Krahmer-Möllenberg.
17393. Joint for railway and tramway rails and for girders. Mitford.
20549. Method of fixing auxiliary guard rails to tramway track rails. Holt and Rhodes.
21633. Railway joints. Richards.
23201. Tramway lines. Wolff.

Crewe; London and North Western Railway.

CREWE is the largest and most important railway centre in this country, if not in Europe, not only on account of the large locomotive works of the L. and North Western R., but for its busy passenger station and extensive goods yards and sorting sidings.

Through the passenger station never less than 300 passenger trains pass each week-day, and at the goods yards traffic is exchanged between the lines from London, Rugby, Birmingham and Stafford on the South; Bristol, South Wales, Hereford and Shrewsbury on the South-West; Holyhead (Dublin, Greenore and Ireland), North Wales and Chester on the West; Liverpool on the North-West; Scotland, Carlisle, Preston, Blackpool, Fleetwood (Belfast and N. Ireland), Wigan and Warrington on the North; Manchester, Leeds and Stockport on the North-East; together with the North Staffordshire line from Derby, Burton and the Potteries and the Great Western from Wellington. Crewe is fairly central geographically on the L. and North Western system, and much more so from a traffic and business point of view. For many years the difficulties of getting the trains through gradually became enormous, and this remark applies to both passenger and goods trains. The L. and North Western R. Company, however, grasped the problem with characteristic energy, and a well-thought-out plan for extensive additions for all classes of traffic was adopted about 11 years ago, the completion of which may now be recorded.

The passenger station has been both widened and lengthened. The number of platform through lines has been increased from four to six, together with the greater length, and the number of bay lines has been increased from six to ten. These additions have greatly assisted the working of the passenger traffic, and there are now no longer the difficulties of getting trains into Crewe, dealing with them promptly and getting them away.

But it was worse with goods trains. There was not only a lack of accommodation for getting the trains through the station, but the space available for all the necessary shunting and marshalling was so limited that much of the goods train work had to be done elsewhere. To efficiently handle the goods traffic it was therefore necessary to provide independent lines through the station and increased facilities for marshalling and exchange. In addition, accommodation had to be made for the scheme adopted 8 or 9 years ago for transhipping the greater part of the goods traffic that not only passed through Crewe, but was handled at the stations within an area of many miles of Crewe.

A consideration of this great scheme would appear to divide itself into four heads:—I., the enlarged passenger station; II., the marshalling sidings; III., the tranship shed; IV., the underground goods lines whereby the goods trains are enabled to pass through Crewe Station without crossing, or otherwise interfering with, the passenger traffic.

I. The Passenger Station.

The accommodation formerly consisted of two island platforms. The lines run approximately north and south, so that the east island platform was for up traffic and the west for down traffic. There were two through lines between the west up main and the east down main, with scissor crossings between the through and platform lines. It may here be remarked that these through lines were not of much value as

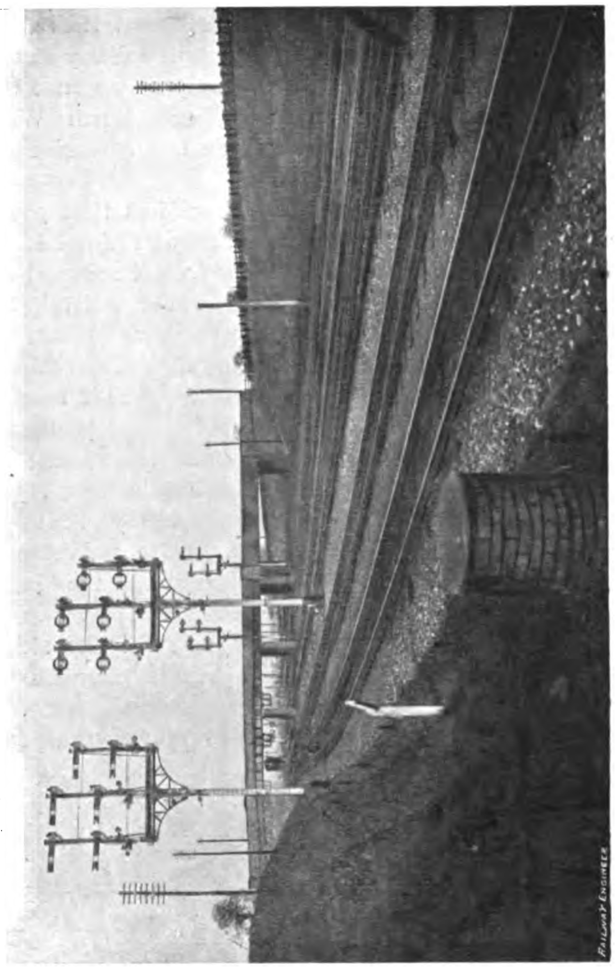


Fig. 1.

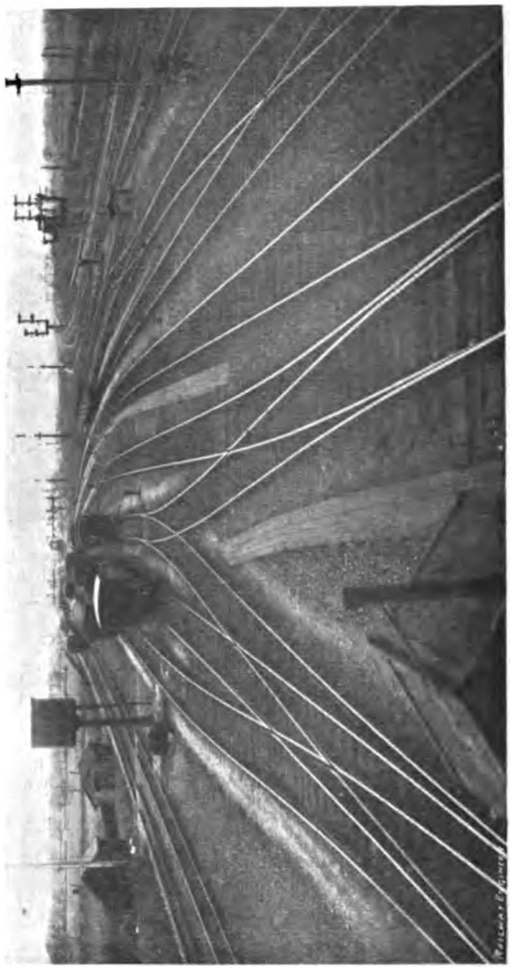


Fig. 2.

such, as engines and extra vehicles for incoming trains had to stand on them. At the south end of the up island platform were two bay lines from which North Staffordshire and G.W. trains used to depart, and at the south end of the down platform were two other bays at which the same Company's trains arrived. At the north end of the same platform were two more bays that were used for local traffic. On the extreme west, and outside the station wall, were a pair of up and down lines over which most of the goods trains passed, also many of the non-stopping express passenger and excursion trains.

It is on the west side, and outside the station wall above referred to, that the station has been widened. The east side of the former up island platform has been lengthened at the south end and the west side of the former down island platform at the north end. The former up through line between the platforms remains as an up through line and the down through has been severed in the centre and converted into a siding on each side of scissor crossings between the up through line and the former east down main. This will be understood by reference to the annexed plan, and there will also be seen a line passing through the centre of the station and entitled "Up and down platform line 3." On the west side of this is the wall already mentioned. The outside up through line has been converted into a down through line; the former outside down through line has been converted into sidings, as in the old station. Then comes a down platform line alongside a noble island platform, 500 yards long and 100ft. wide, on the west side of which is another down platform line and outside this a down through line. There are scissor crossings between the lines known as the Down Through Line 2 and the Down Platform Line 2 and the Down Through Line 1 and the Down Platform Line 1. South of the latter scissor crossings is a siding between the two last named lines. At the north end of the new platform are two bay lines, and at the south end there are also two bay lines which have a "run-round" siding between them.

The new platform is known as Nos. 1 and 2 platform—No. 1 being on the west side—the former down platform is Nos. 3 and 4 and the former up platform is Nos. 5 and 6.

The accommodation now consists of six platform lines—three up and two down and one up and down ten platform bay lines and three through independent lines. Four sets of

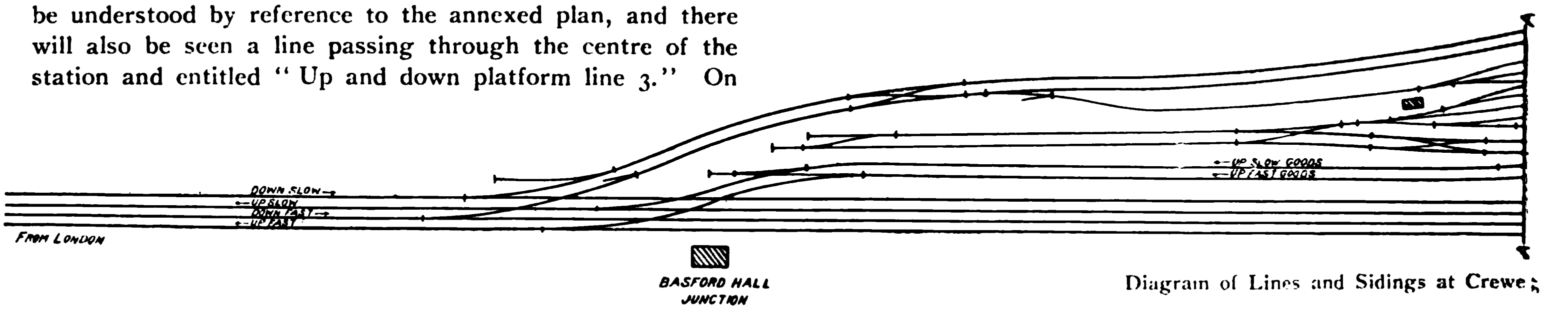


Diagram of Lines and Sidings at Crewe;

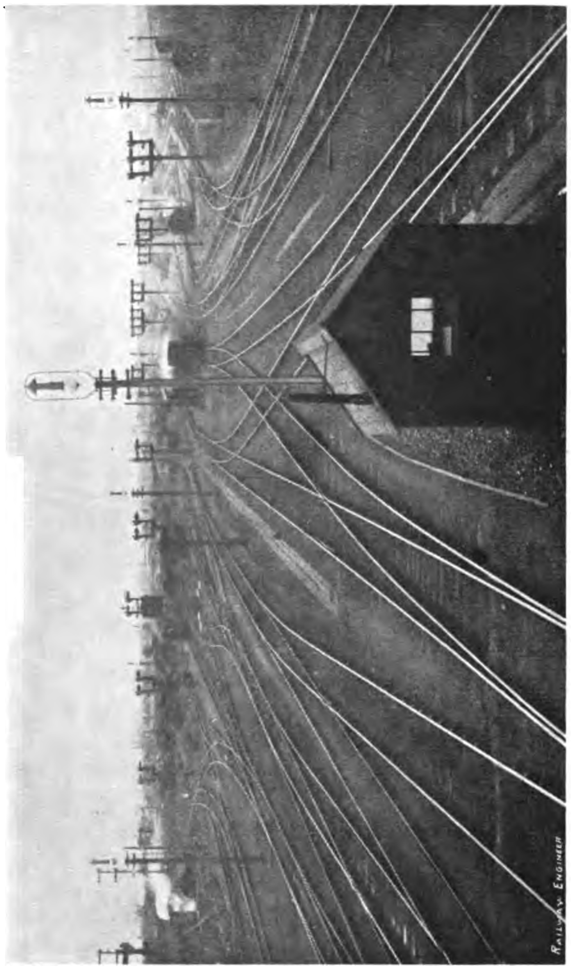


Fig. 3.

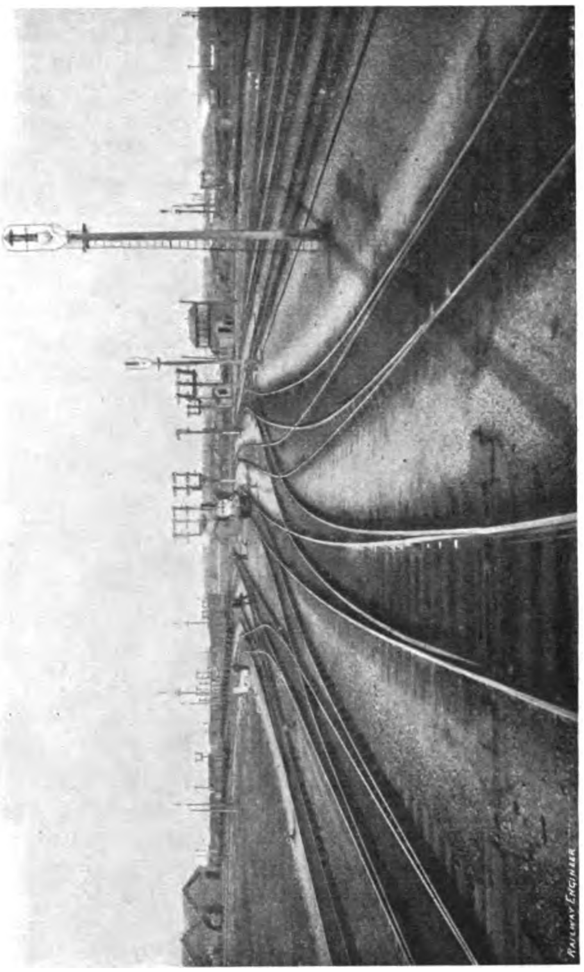


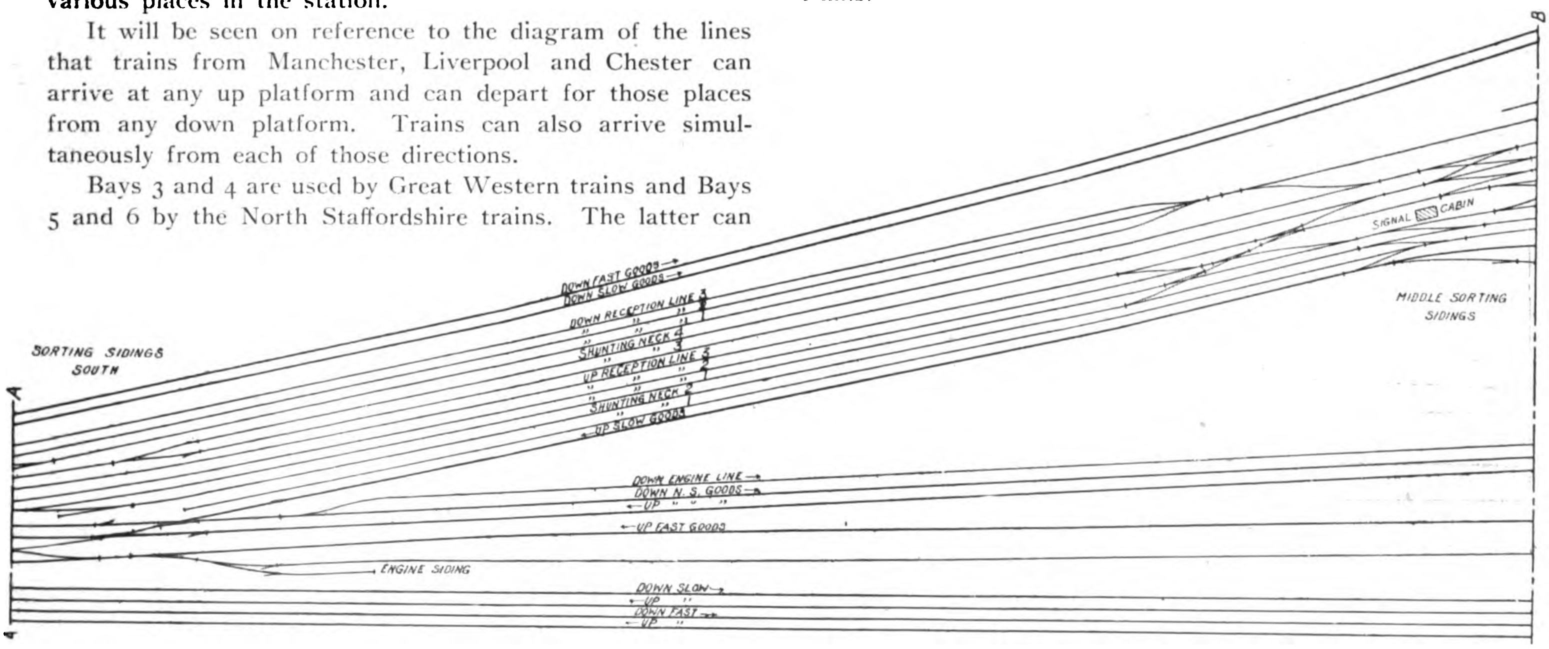
Fig. 4.

scissor crossings are provided whereby trains can arrive on the through lines and pass to the platforms in advance of other trains, and trains can depart from the platform lines through the scissor crossings and get in advance of other trains at the platforms. The middle sidings are used for the accommodation of extra vehicles for strengthening and other purposes and for standing engines whilst waiting for their trains. There is also plenty of siding accommodation at various places in the station.

It will be seen on reference to the diagram of the lines that trains from Manchester, Liverpool and Chester can arrive at any up platform and can depart for those places from any down platform. Trains can also arrive simultaneously from each of those directions.

Bays 3 and 4 are used by Great Western trains and Bays 5 and 6 by the North Staffordshire trains. The latter can now arrive and depart independently of the main lines at the South Junction.

On the west side a large dock for dealing with horses and carriages has been erected. This has been made of ample proportions in order to make provision for dealing with the traffic to and from the very important and largely attended Horse Sales. For a recent sale no less than 1,266 horses were brought by rail to Crewe, most of which came by passenger trains.



London and North Western Railway.

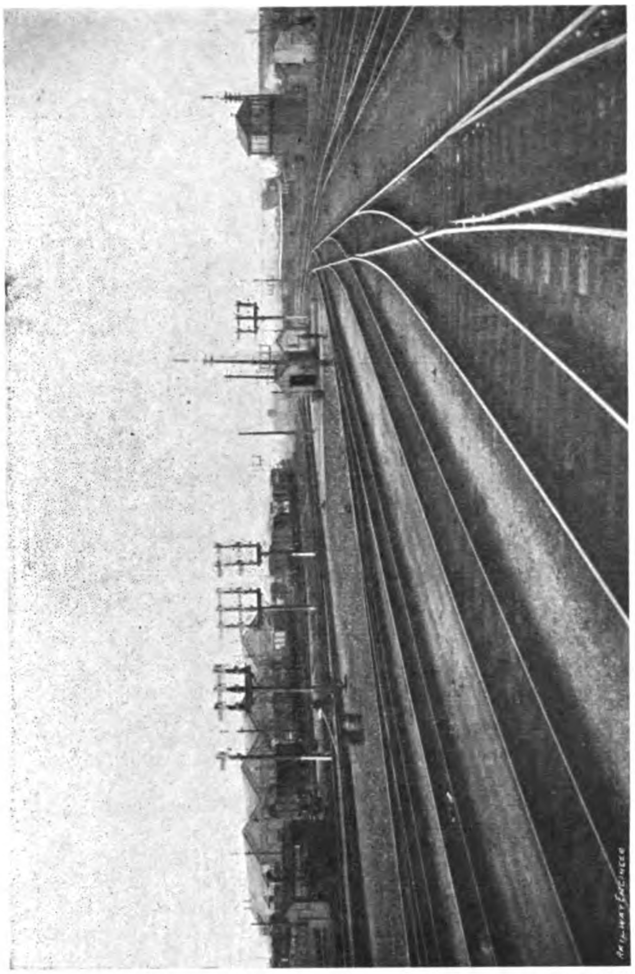


Fig. 5.

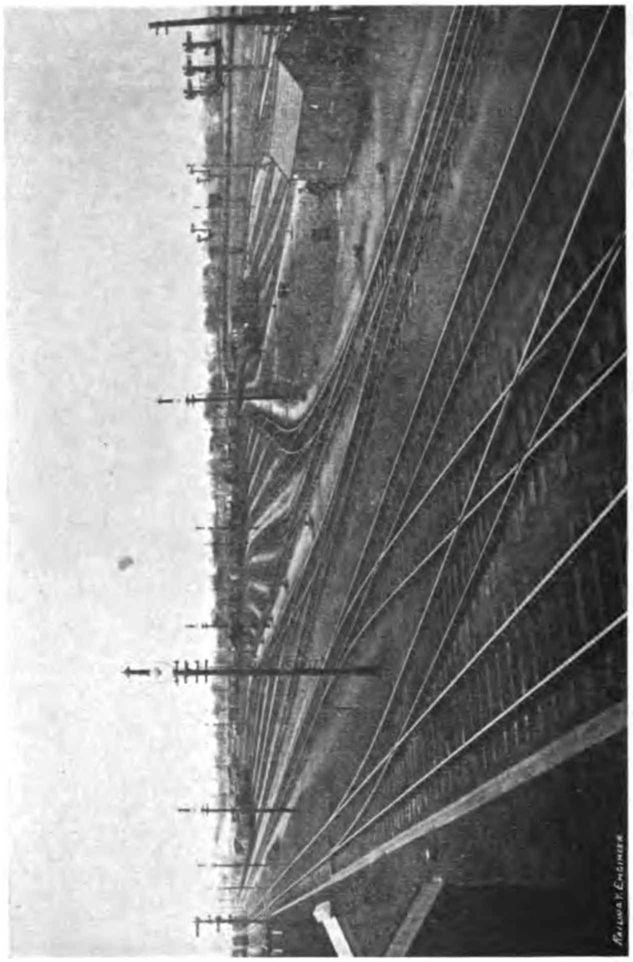


Fig. 6.

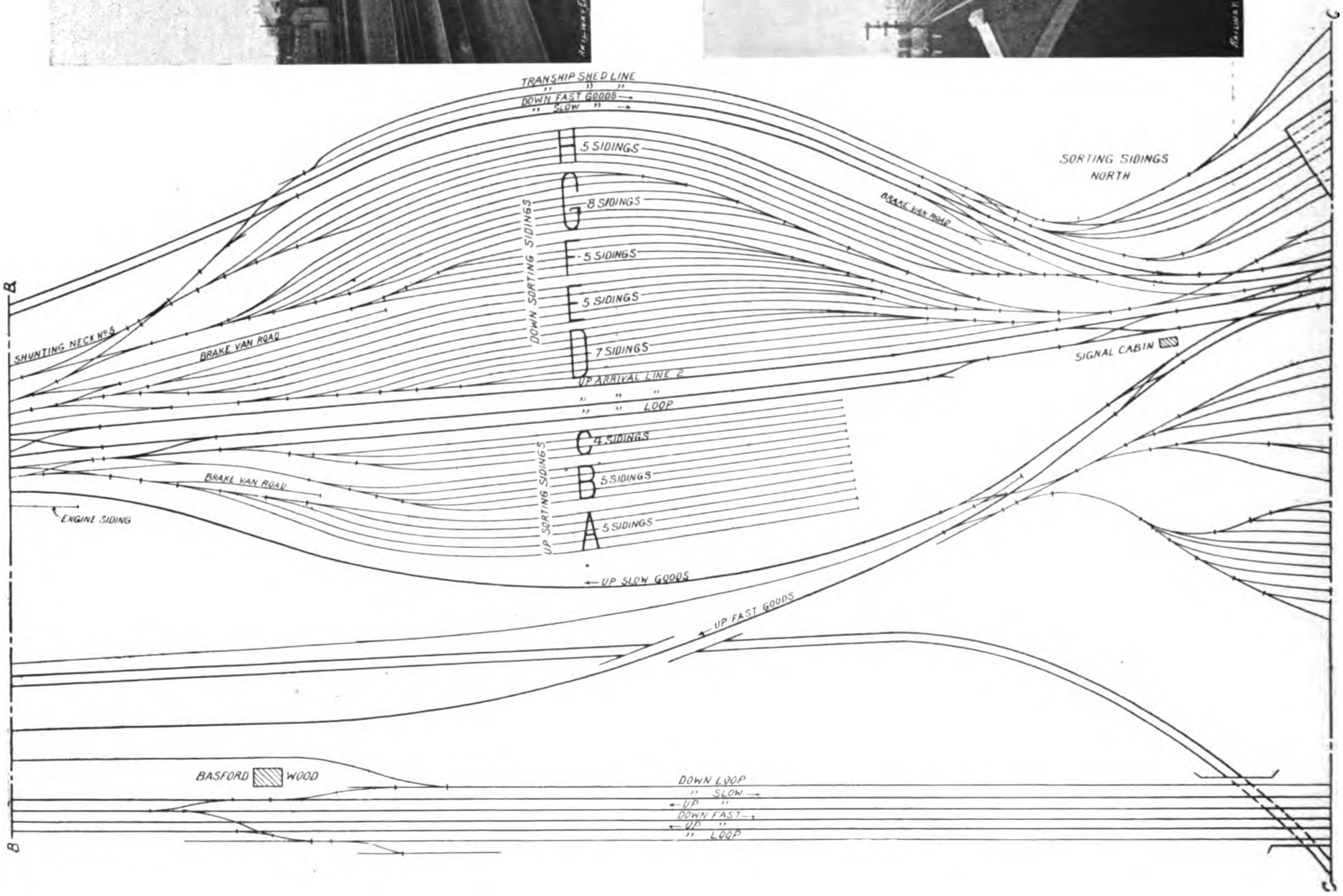


Diagram of Lines and Sidings at Crewe;

In addition to the former footbridge, with its exit and entrance on Nantwich Road, a footbridge has been provided further south as shown, with steps on each island platform. There is also a subway for luggage and parcels which not only serves each platform, but extends as far as the parcels office, which is at the end of the horse and carriage dock.

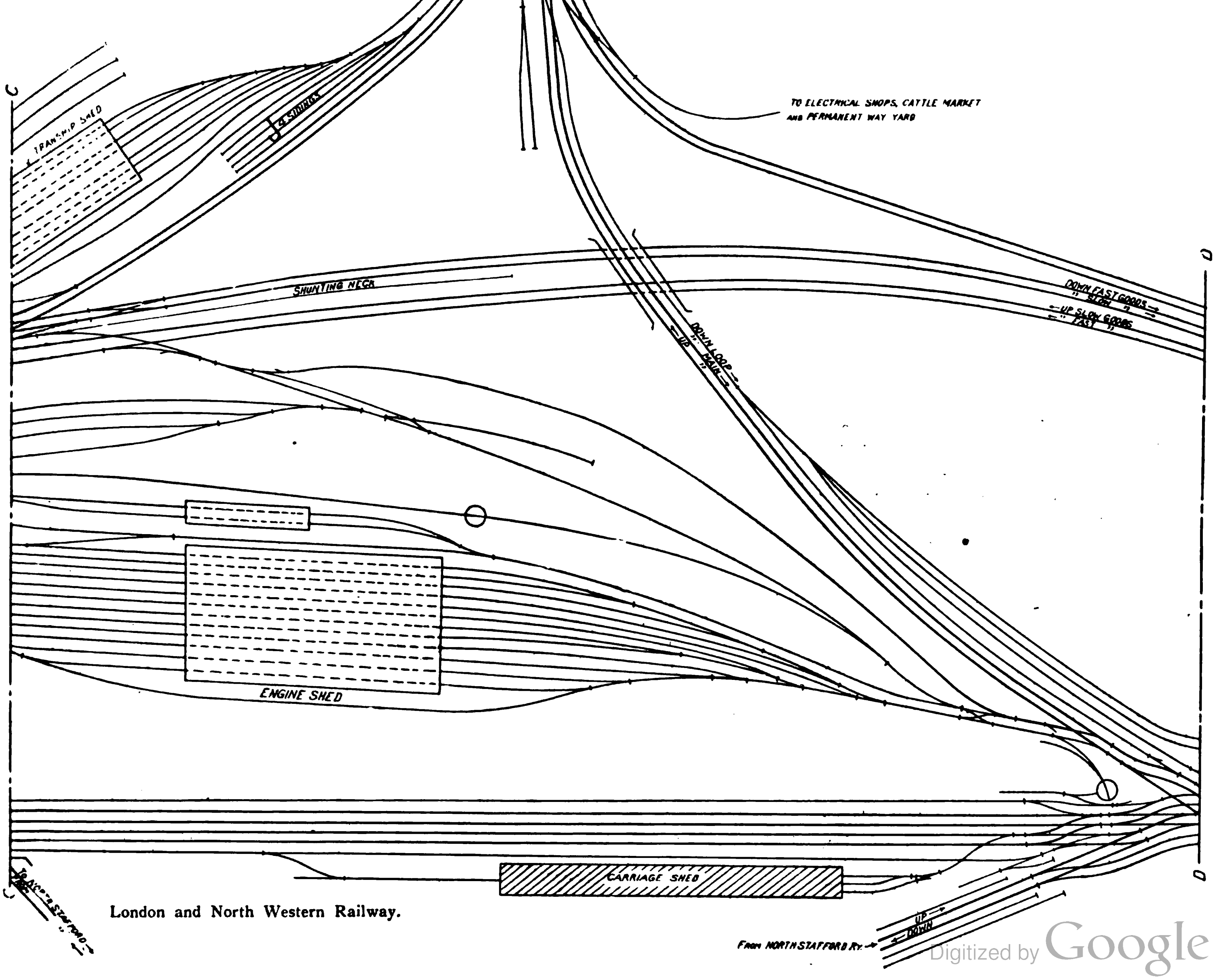
The area of the station is 70,000 square yards, of which 47,000 sq. yards is roofed in. There are each week day 146 up passenger trains through Crewe, and 162 down trains. There are also 108 complete movements of empty carriage trains. About 182 engines use the old engine-shed at the north end of station on the Chester lines and 100 use the new shed in the angle between the main south and the Shrewsbury lines.

The signalling of Crewe has been fully described in the *Railway Engineer*, particularly in the issues of August, 1906 (p. 259) and February, 1907 (p. 43). All the points and signals in the station—also in the marshalling sidings—are operated by electrical power by the "Crewe" system, which is fully described in Raynar Wilson's *Power Railway Signalling*. Connected with the station there are four such power-operated signal-boxes as follows:—North Junction, 266 levers, South Junction 247 levers, Station A 26 levers, Station B 26. The Scissors Crossing box contains 36 levers, mechanically operated. In the notice in the *Railway Engineer* for February, 1907, there is a view of the interior and exterior of the North Junction box and a diagram of the lines, points and signals. Reference is also made therein to the remarkably quick engineering feat performed here on November 4th, 1906, when the old box, containing 200 mechanical levers, was thrown out of use and removed and the entire permanent way of the junction re-arranged and the points and signals connected up to the new power-operated box in 24 hours.

The station and offices are lighted by 152 arc lamps and 515 incandescent lamps.

II. *Marshalling Sidings*.

The extent of the marshalling sidings will be appreciated by the accompanying diagram. The southern end is controlled from Basford Hall Junction signal-box. At the northern end there are four goods lines which become six—two for



London and North Western Railway.

Chester and Holyhead, two for Liverpool and the North, and two for Manchester and Yorkshire. There are also two for the Shrewsbury direction and two for the North Staffordshire R. It must be understood that the diagram is not intended to show details, and it is not drawn to scale.

Leaving the down fast and the down slow main lines at Basford Hall Junction are two lines which skirt the westward boundary of the marshalling sidings. The outer of these is the down fast goods and the other is the down slow goods. Commencing at Sorting Sidings North box is the up fast goods line and the up slow goods line, both of which are on the east side of the sidings and which join the up fast and up slow main lines at Basford Hall Junction.

The fast goods lines are only used for trains that call at the sidings for water and examination purposes. Through goods trains that have wagons to leave, or to pick up, at Crewe use the slow goods lines. The down trains do such work at the Sorting Sidings North box and up trains at Sorting Sidings Middle box.

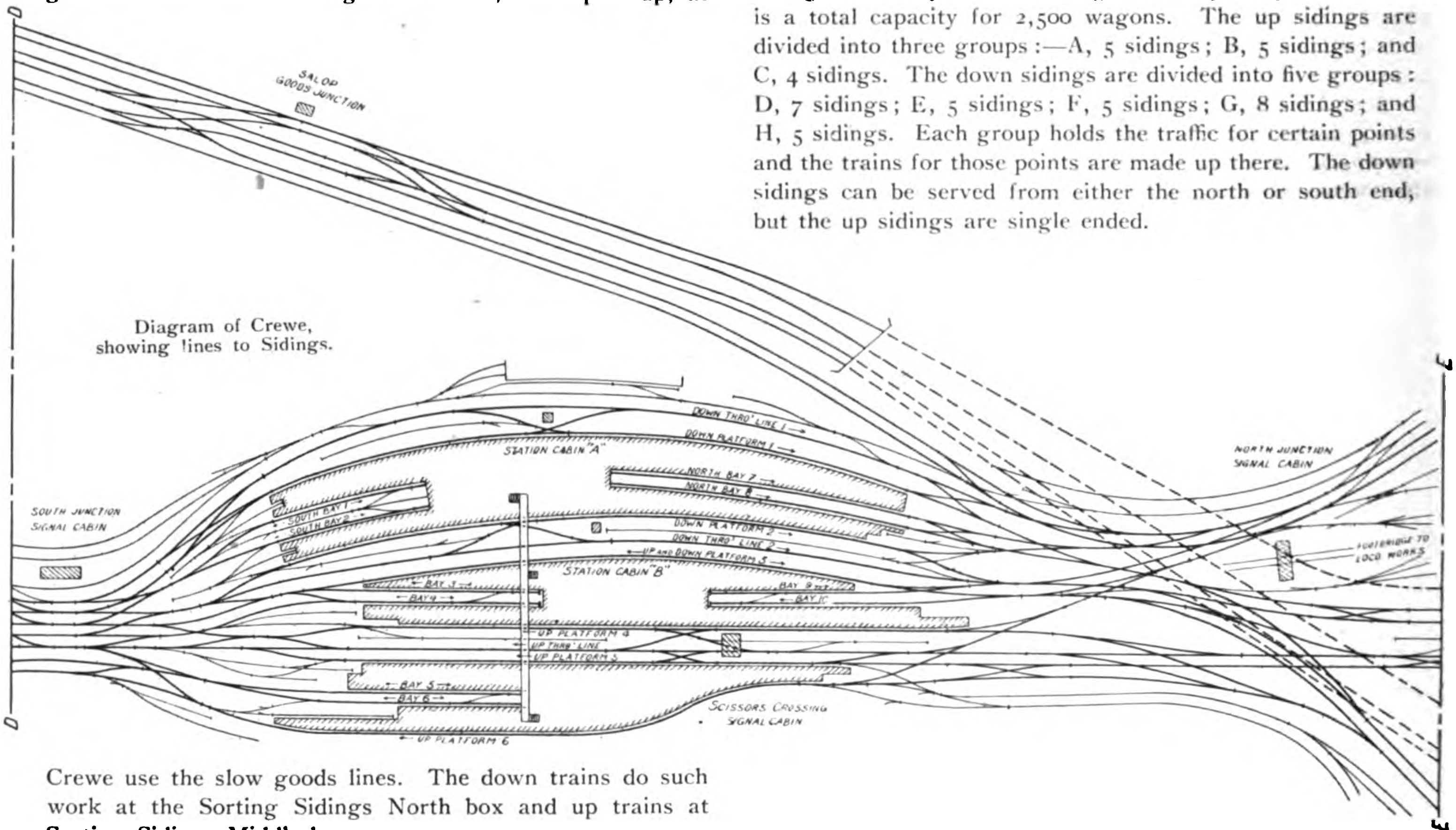


Diagram of Crewe, showing lines to Sidings.

Between the up fast goods and up slow goods lines are an up and a down line for trains to and from the North Stafford line. On the North Stafford line there is a yard which has a connection with the line to Basford Hall, and off the line from Basford Hall there is direct access to the down main line of the North Staffordshire Railway also into their yard. Between the line to the N.S.R. and the up slow goods line there is a third line, which is an independent engine line to the shed.

Between the down slow goods and the up slow goods there are, at the south end, ten lines. The three most westerly are reception lines for down trains which are broken up at Crewe. Any one of these lines can be entered direct from off either the down fast goods or down slow goods. Then come shunting necks Nos. 4 and 3, which are used for movements in and out of the down sorting sidings. East of these are three reception lines for up trains which are broken up at Crewe, and which enter these reception lines direct from Up Arrival Line 1 or Up Arrival Line 2. Then come Shunting Necks Nos. 2 and 1, used for movements in and out of the up sorting sidings.

Fig. 1 is a view looking north from a point on the west side of the lines opposite Basford Hall Junction signal-box. The nearest line is the down fast goods line, the next the down slow goods line, and then the two shunting necks that are a continuation of the two North Stafford lines. Fig. 2 is a view looking north out of Sorting Sidings South box. On the left are the two down goods lines. In the foreground, with wagons standing on them, are the three down reception lines. To the right of the wagons and on the left of the electric light standard are shunting necks Nos. 4 and 3.

There are 14 up sorting sidings and 30 down sorting sidings, each capable of holding at least 50 wagons. There is a total capacity for 2,500 wagons. The up sidings are divided into three groups :—A, 5 sidings; B, 5 sidings; and C, 4 sidings. The down sidings are divided into five groups: D, 7 sidings; E, 5 sidings; F, 5 sidings; G, 8 sidings; and H, 5 sidings. Each group holds the traffic for certain points and the trains for those points are made up there. The down sidings can be served from either the north or south end, but the up sidings are single ended.

Fig. 3 is a view looking north from out of Sorting Sidings Middle signal-box. The three-arm bracket signal on the extreme right is from sidings A, that to the left thereof —with rings on the arms—is from sidings B. Behind this and slightly to the left is the signal for sidings C. Then, standing alone, come the three-arm signal from the Up Arrival Loop and the four-arm signal from Up Arrival Line 1. To the left again, and almost hidden by the electric light standard in the foreground, is the two-arm signal from Up Arrival Line 2. Then further to the left, and in order, come the signals from sidings D, E, F, G, H—each two-arm signals. The two two-arm high signals on the extreme left apply to the down fast goods line and—those with rings on the arms—to the down slow goods line.

At Sorting Sidings North signal-box is the northern end of the yard. From here northward are four lines—two up and two down—up to Salop Goods Junction, and which pass

Fig. 7.

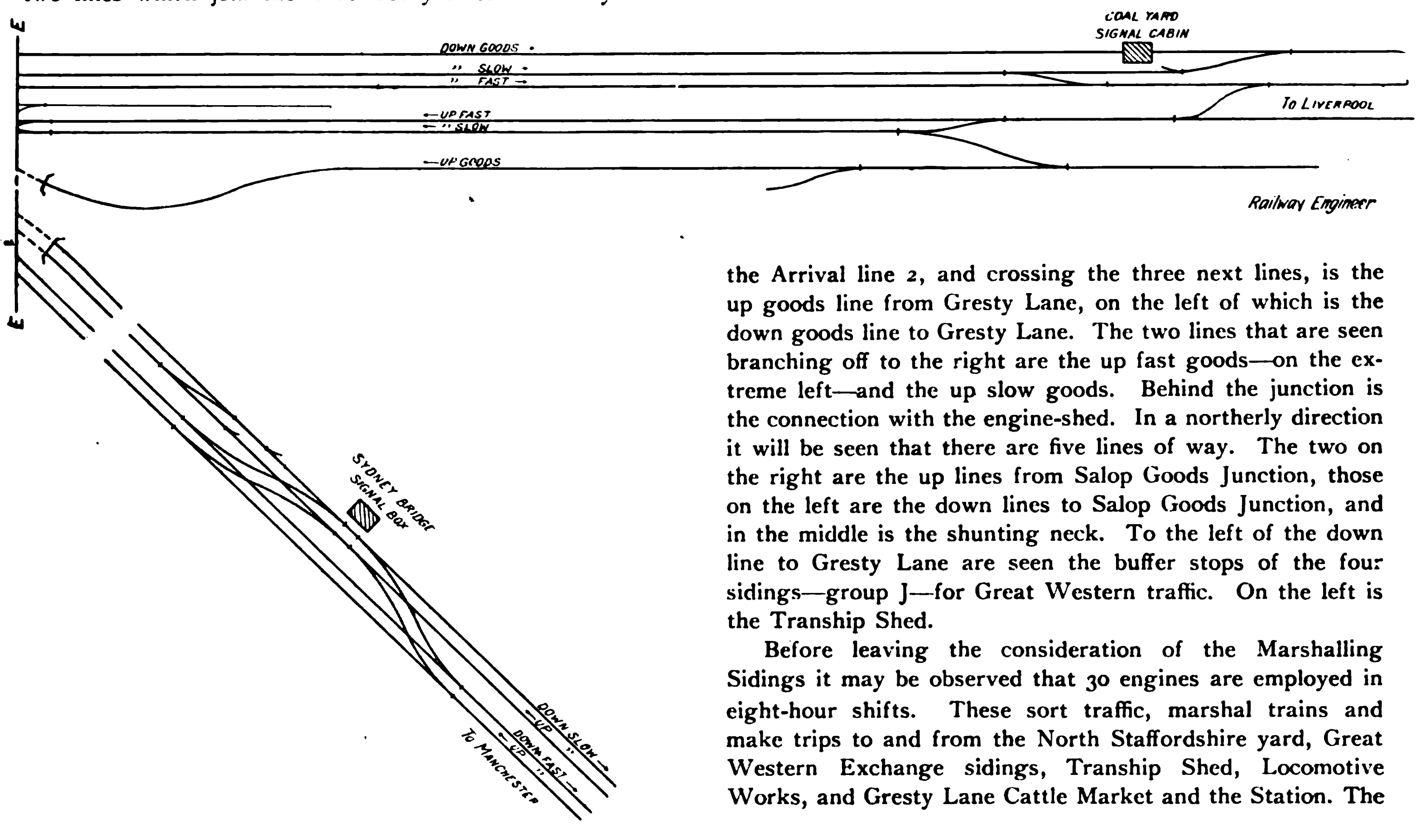
under the Shrewsbury passenger lines, thereby removing a great obstacle to prompt working of trains. To the west are two lines which join the Shrewsbury lines at Gresty Lane signal-box. To the south of the Gresty Lane lines is the Tranship Shed. Controlled from the same box are the five up lines already referred to—up fast goods, up slow goods, arrival loop, arrival 1 and arrival 2. There are also two separate connections to and from the engine shed.

Between the two down lines and the two up lines that lead to and from Salop Goods Junction is a shunting neck.

Fig. 4 is a view, looking northwards, taken from a point on the down fast goods line—the centre line in the foreground. The two lines to the left are the Tranship Shed lines, which run to the west of the down fast goods line as far as the Sorting Sidings Midale box. The Tranship Shed is seen in the distance on the left. Fig. 5 is a view taken further east. The lines in the foreground are those governing access to sidings E, F, G, and to the right are sidings D. To the left are sidings H.

Fig. 6 gives a very good idea of the marshalling sidings. It is taken from the Sorting Sidings North box and looks south. The two lines on the left, with the electric light standards between, are Arrival Line 2 (on the left) and Arrival Line 1. The facing points, in the distance, in Arrival Line 1 lead to the Arrival Loop, and to the left of these are the up sorting sidings. To the right of Arrival Line 1 are three fans of sidings. The first ladder is for the seven sidings in group D. The next ladder leads to groups E and F, and the third ladder is for the eight sidings in group G. The ladder for the five sidings in group H is behind the inspectors' office on the right. Then outside, where the water-columns and the two two-arm bracket signals stand, are the down fast goods and down slow goods lines.

Fig. 7 is a view from the same box in the opposite direction—northwards. In the foreground are the two Arrival lines—Arrival line 1 being on the right. The connection in



the Arrival line 2, and crossing the three next lines, is the up goods line from Gresty Lane, on the left of which is the down goods line to Gresty Lane. The two lines that are seen branching off to the right are the up fast goods—on the extreme left—and the up slow goods. Behind the junction is the connection with the engine-shed. In a northerly direction it will be seen that there are five lines of way. The two on the right are the up lines from Salop Goods Junction, those on the left are the down lines to Salop Goods Junction, and in the middle is the shunting neck. To the left of the down line to Gresty Lane are seen the buffer stops of the four sidings—group J—for Great Western traffic. On the left is the Tranship Shed.

Before leaving the consideration of the Marshalling Sidings it may be observed that 30 engines are employed in eight-hour shifts. These sort traffic, marshal trains and make trips to and from the North Staffordshire yard, Great Western Exchange sidings, Tranship Shed, Locomotive Works, and Gresty Lane Cattle Market and the Station. The

growth of traffic may be judged from the number of wagons attached to trains during the month of October of the years 1903-7. They are as follows :—

October, 1903	...	139,974	wagons attached.
" 1904	...	148,359	" "
" 1905	...	165,093	" "
" 1906	...	174,315	" "
" 1907	...	197,236	" "

The totals for the complete years are :—

Year 1904	...	1,685,083	wagons attached.
" 1905	...	1,776,850	" "
" 1906	...	1,882,004	" "
" 1907	...	2,085,494	" "

The average number of wagons attached during October, 1907, was 6,556 per diem, but as this includes Sundays and Mondays—both slack days the number frequently exceeded 7,000 a day. The highest record so far is 7,600 on September 26th, 1907.

These figures are for wagons attached only; were those detached also counted the number would be about doubled.

The number of booked through trains for each week day is 85. There are 120 trains booked to commence at Crewe and 105 to terminate there, so that 310 trains are dealt with each week-day in the marshalling sidings. In addition, there are about 80 trips daily to the Tranship Shed, Wagon Repairing Shop, Great Western exchange sidings, North Staffordshire Yard, Crewe Works, Engine Sheds, Electrical Shops, etc. The number of wagons for the three latter places average 250 per day.

The three signal-boxes in the sidings are all operated by electrical power on the "Crewe" system, and are manned in eight-hour shifts. In the Sorting Sidings Middle box there are two frames, and two signalmen work in each shift. The boxes are :—Sorting Sidings South, 76 levers; Sorting Sidings Middle, 152 levers; Sorting Sidings North, 95 levers. Salop Goods Junction and Gresty Lane are operated similarly, each having 75 levers. Basford Hall Junction has 80 mechanically operated levers.

As will have been noticed from the views, the sidings are lighted by electric arc lamps of 8½ ampères, equal to 2,000 c.p. each, with a minimum candle power of 1,500. There are 132 lamps, which are 30ft. above rail level and placed 60 yards apart, except at the shunting necks, where they are 30 yards apart, so as to concentrate the light where most wanted.

The power for lighting the station and yard, for operating the lifts in the station and the cranes and capstans at the Tranship shed is generated in a power house erected near the North Engine Shed. This contains five 120 H.P. sets of 230 volt Crewe-made dynamos coupled direct to Willans and Robinson triple-expansion engines, two 120 H.P. sets of 660 volt Crewe-made dynamos, and two 50 H.P. sets of 660 volt Crewe-made dynamos coupled direct to Willans and Robinson high speed triple-expansion engines. Two Lancashire Dynamo Co.'s dynamos, 660 volt, 165 H.P., direct driven by Belliss and Morcom engines, and a battery of 120 cells, Chloride Electrical Storage Co.'s make, 1,000 ampère hours.

(To be continued.)

Portable Acetylene Flare Lights.

We recently had an opportunity of inspecting the Portable Acetylene Flare Lights, of which Messrs. C. C. Wakefield and Co., 27, Cannon Street, London, E.C., are the patentees and sole manufacturers.

Oil flare lights have been largely and successfully used mainly because there was nothing else on the market, and emergency, permanent way, bridge, and breakdown work has generally been carried out by their assistance at night time. But the faults and disadvantages of the oil flare are

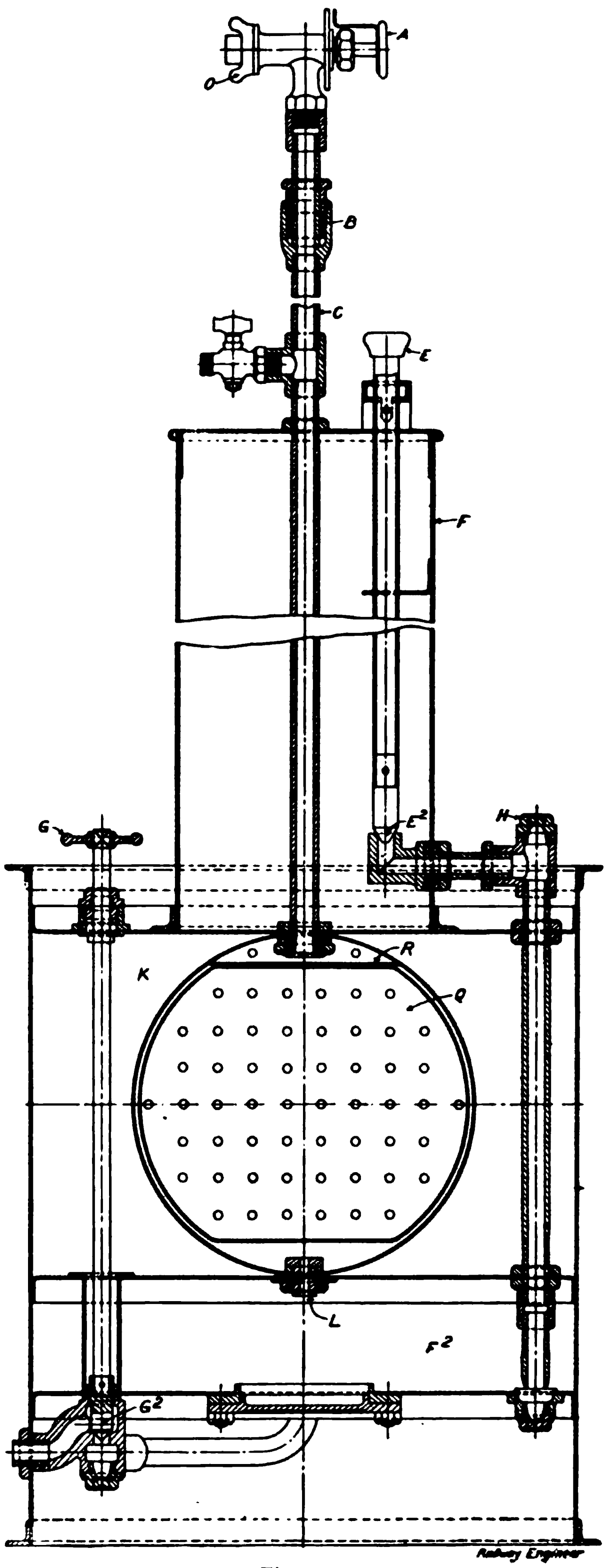


Fig. 1.

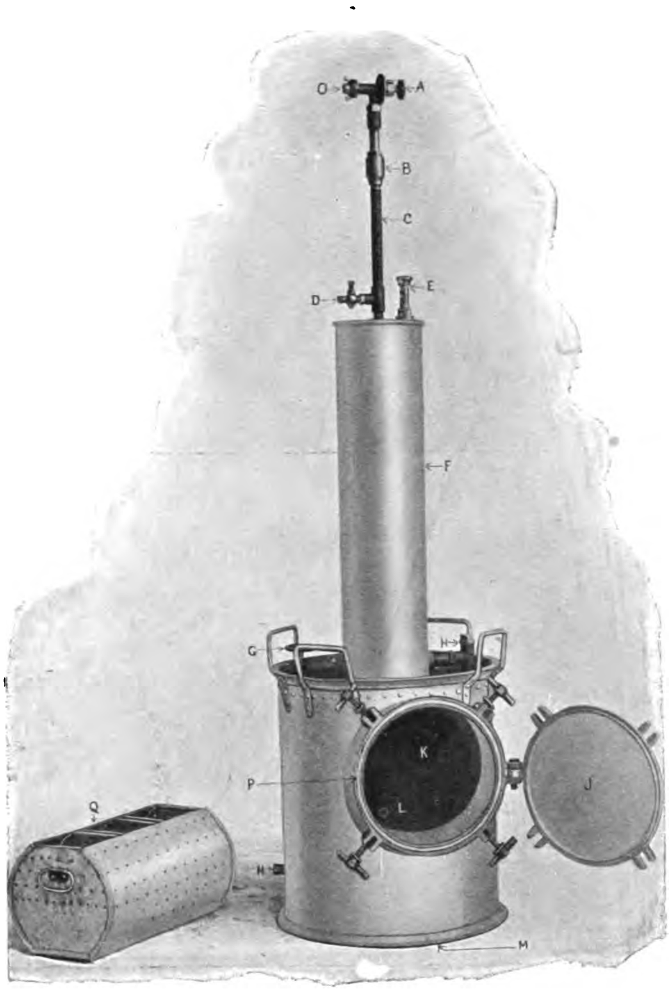


Fig. 2.

well known to engineers and contractors, and on the grounds of safety, cleanliness and convenience acetylene should commend itself.

Figs. 1, 2 and 3 illustrate the lamps, which are made in two sizes, to burn 6 and 12 hours (when giving a light of 3,000 c.p.) respectively. Fig. 3 also shows a small hand lamp, of which fig. 4 is a larger illustration.

The weight of the 6-hour size is 105lbs. empty and 198lbs. when fully charged with carbide and water; the 12-hour size weighs 140lbs. empty and 300lbs. charged. The standing space required does not exceed 22ins. and 24ins. square for the two sizes respectively; the heights to the top of the reservoirs are 4ft. 2in. and 4ft. 5in. and to the burner 5ft. 9in. and 6ft. respectively.

Fig. 1 shows the interior of the lamps, which, it will be observed, is very simple, and well able to bear with the rough usage which all railway and contractors' plant is generally subjected to.

The beauty of the light produced by acetylene cannot be disputed, as it approaches day-light more nearly than any other artificial light.

The gas in these lamps is made on the water to carbide principle. The carbide is placed in the containers Q, which are divided by double partitions into three compartments, which have the holes admitting the water at different levels, so that the three lots of carbide are attacked in succession. The containers—filled only about half full to allow for the expansion of the carbide—are placed in the retort K, and the door J is closed and screwed up gas and water tight on a rubber packing ring P. The plate R across the retort is to prevent the possibility of the carbide choking the gas outlet when it swells. The reservoir F is filled with water, and the lamp is then fully charged ready to make gas.

When the light is required the knob E is lifted and turned through a right angle. This movement lifts the peg on the rod attached to E out of its slots and rests it on the ledges of the guide as shown. At the lower end of rod on E is a conical valve E^2, through which the water passes down the pipe H to the chamber F^2, which it fills, and then through the water inlet L to the retort K, in which is the carbide container Q. Gas is immediately generated, and expels the air from gas chamber through the gas pipe C and the burner, and is then ready to be lighted.

The burner is adjustable, and by simply turning a disc A (provided with a pointer) may be regulated to give a flame of from 500 to 5,000 c.p., the correct positions for the disc being clearly marked on the back of the burner. The burner is provided with a conical reflector fixed by a thumb screw O, and by means of the packed joint at B the light can be turned to the direction required without moving the lamp.

The generation of the gas is controlled automatically. If the burner does not consume the gas as fast as it is made the pressure in the gas chamber rises and the water is forced

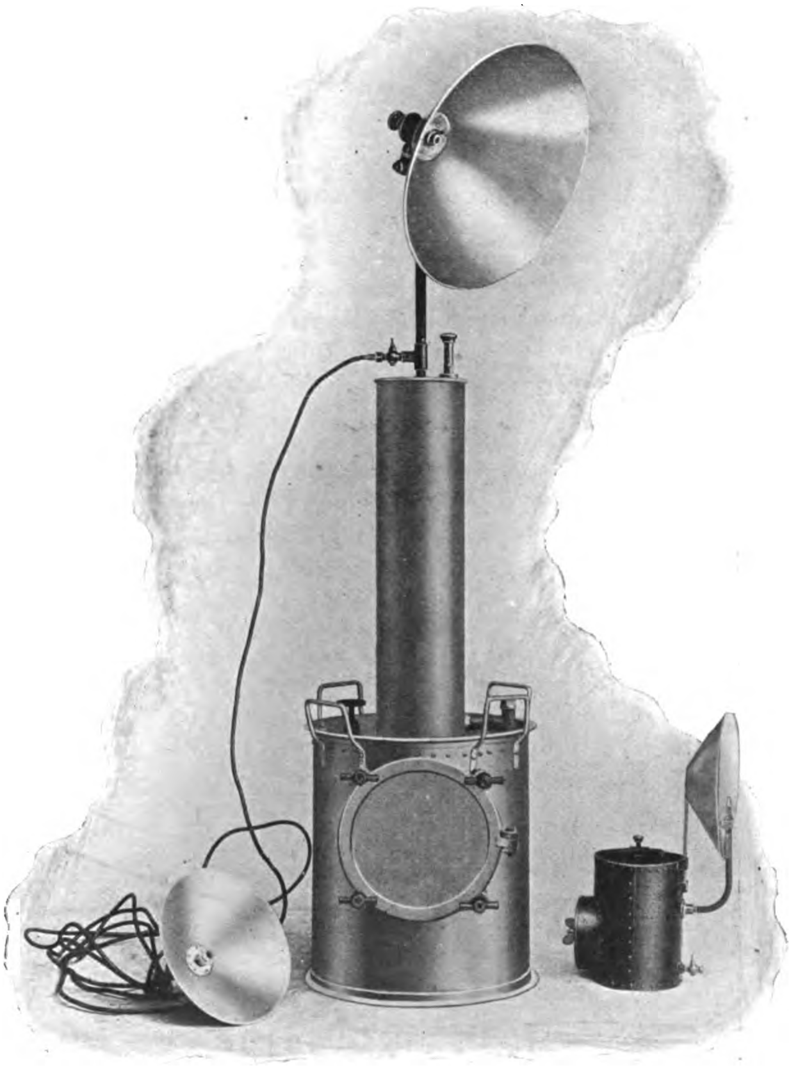


Fig. 3.

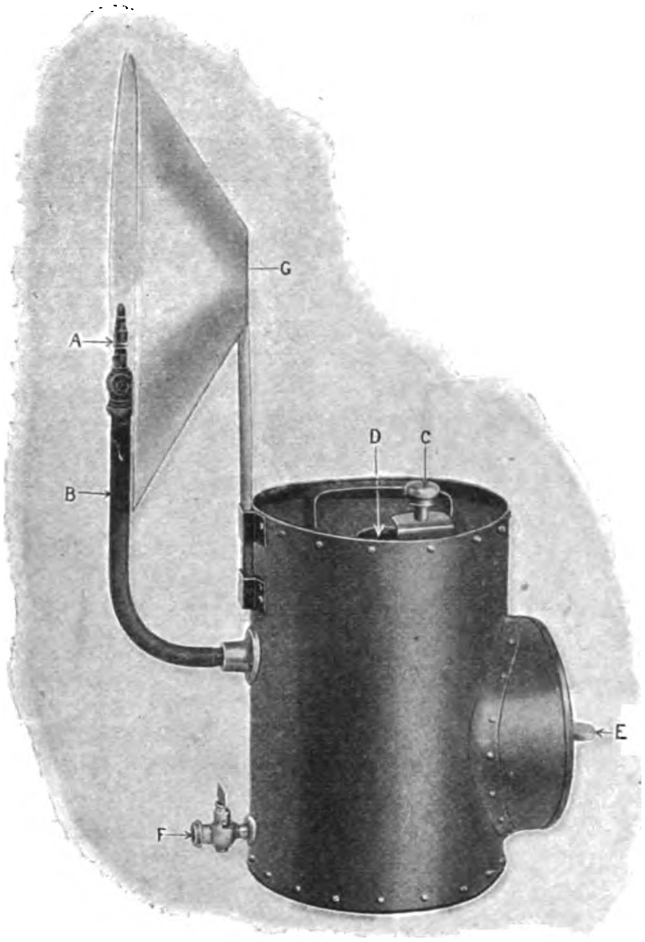


Fig. 4.

Fig 5.

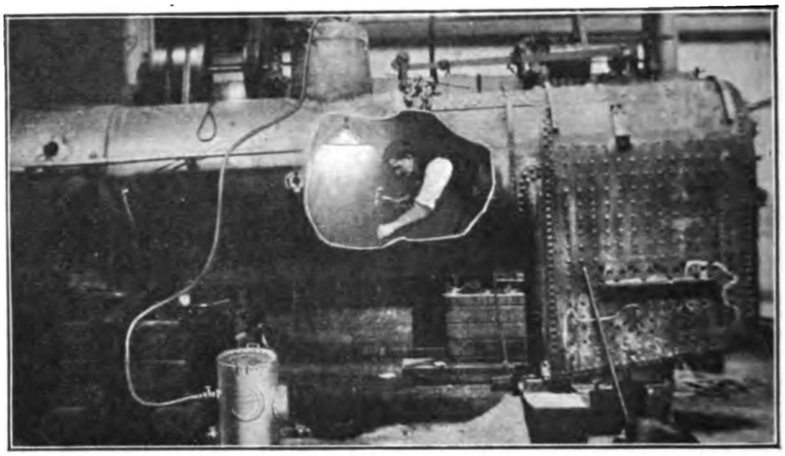


Fig. 6.

down away from the carbide and up the pipe H into the reservoir F and the generation of gas is retarded. If the water overflow the top of the reservoir no harm results, as it simply shows that the gas is temporarily taking the place of the water. Should generation of gas be continued after valve E^2 has been closed, a pressure of 5lbs. is sufficient to open this valve. Anything in the nature of an explosion cannot take place.

When the light is not required the valve E^2 is closed and the drain valve G^2 is opened by means of the hand wheel G; the light then soon burns itself out, and the remaining unexhausted carbide is preserved for use at another time, when the lamp can be relighted by re-admitting the water as explained above.

It will be seen from the drawing that the pipes and valves can be cleaned without difficulty, that no waste of gas can take place, and that once started the light requires no attention.

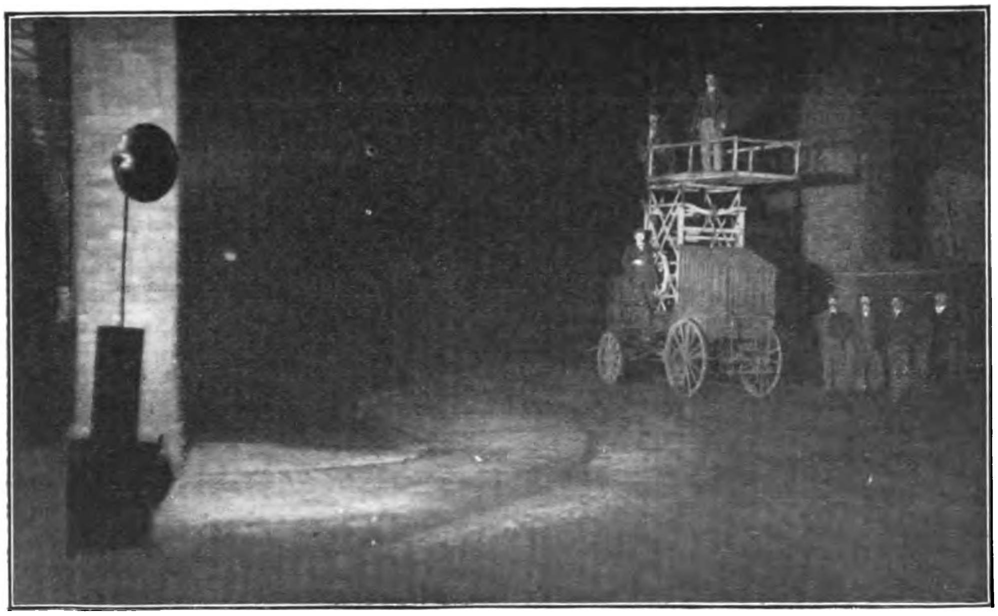


Fig. 7.

The Hand Lamp, fig. 4, weighs empty 11¼lbs. and fully charged with carbide and water 18lbs. The reservoir is 10ins. high and 7ins. wide; the height to the top of the reflector 21½ins. The full charge of carbide will give a light of 100 c.p. for 10 hours, or proportionately longer if a smaller frame be used.

In this lamp the gas generation is automatically controlled in a very similar way to that described above, but in this case the water is allowed to drip on to the carbide.

The larger lamps are provided with four handles through which bars can be threaded, and two men can then carry them very easily.

The uses to which these lights can be put on railways are innumerable, but they would seem to be particularly suited to form part of the equipment of every break down train.

Fig. 5 is a view of these lamps lighting a crane at work, and fig. 6 shows one of these lights (fitted with a flexible pipe) inside a locomotive boiler. For such positions acetylene is only surpassed by the electric light as the flame gives no smoke, carbonic oxide gas or sulphur, and very little heat, while its illuminating power is 15 times that of coal gas.

Fig. 7 illustrates the quality of the light, as it is reproduced from a photograph taken at Bolton at 11.30 p.m. on a very wet (raining) night with an exposure of 30 seconds. Neither the negative or the photograph have been touched up. The light was 20 yards from the tower wagon, which was 30 yards from the camera.

Official Reports on Recent Accidents.

At **Bolton Brow, Halifax Corporation Trams.** *On 15th October, Lt.-Col. E. Druitt, R.E., reports that:—*

Tramcar No. 64 was ascending Pye Nest Road when it got out of control, ran back down the steep hill, left the rails at a curve in Bolton Brow, Sowerby Bridge, and overturned after coming in contact with a wall. Four passengers and the conductor were killed, and 37 were injured.

The car had four wheels and a top deck, weighed, empty, 7½ tons, and seated 22 passengers inside and 26 outside. It was equipped with two 35 horse-power motors, geared direct to the axles, and fitted with three brakes, viz. (*a*) mechanical slipper brake on both rails, applied by worm gearing on a vertical spindle actuated by a hand wheel, (*b*) wheel brakes actuated by hand in the usual manner, and (*c*) rheostatic electric brake. The gauge of the tramways is 3ft. 6ins.

Pye Nest Road is on a gradient averaging about 1 in 15. The car left the rails about 690 yds. from where it commenced to run back. It was on a curve to the left of 160ft. radius, and with a super-elevation of the outer rail of ¾in. On leaving the rails the car ran across the road and footpath and came in contact with a projecting angle of a wall, which sheared the car top right off the underframe, and the latter was then overturned into the roadway. The car top was about 30 yds. and the underframe 50 yds. beyond the point of derailment.

The regulations for the conduct of the traffic in Pye Nest Road are as follows: Speed 4 miles an hour on the downward journey and 6 miles an hour on the upward journey.

All cars must come to an absolute stop before entering Pye Nest Park, and motormen must here be sure that brakes, sand device, etc., are in good working order. When the rails are in bad condition any morning for first car down the motorman should have the rails sanded on curve both on the up and down lines before entering the Park. He should also bring his car to a stand before rounding other curves on this section, and sand both lines as above.

Other regulations for the Halifax Corporation Tramways lay down:—

No. 75. In the event of a car starting to run backwards the first duty of the conductor is to drop sand at his end and keep the sand running until the car is stopped; at the same time apply slipper brake as quickly and as hard as possible. Do not touch the hand brake unless the motorman gives the signal (four bells) to do so.

No. 103. Where possible conductors should endeavour to collect their fares in such a manner that they will be free to remain on rear platform when on steep grades whether ascending or descending.

The Board of Trade Regulations for the Halifax Corporation tramcars as regards brakes are:—

The wheels shall be fitted with brake blocks which can be applied by a screw, or other means, and there shall be in addition an adequate electric brake and a slipper brake or other track brake approved by the Board of Trade for use on the tramways.

They shall also be fitted with a scotch or other device for preventing them from running backwards.

The circumstances attending this unfortunate accident were as follows:—

Driver T. H. Simpson left the depôt with car No. 64 at 4.45 a.m. on 15th October, after satisfying himself that it was in proper working order, for which a quarter of an hour is allowed. He took the car down the steep gradient in Pye Nest Road quite safely and went out to the terminus of the route at Triangle. On the return journey the last stopping place before the accident was in Bolton Brow at the bottom of Pye Nest Road, and the car left this with a full load of passengers. The actual number is not known, but several were standing up inside the car in addition to the 22 for whom there is seating accommodation, and there were about 20 outside. It was a damp morning, so passengers naturally tried to get under cover. The car went up the road as usual, and round the first curve and also partly round the curve opposite Edward's Road, when the current went off, owing to the circuit breaker for this section of the lines coming out at the central generating station. Just previous to this the driver states he had to use sand as the wheels began to slip.

He states that the action he took when the current failed was as follows:—

"I at once pushed the controller round to the 'off' position and put on the wheel brake. This did not hold the car, so I took a second pull at the brake and then the wheels skidded. I then released the wheel brake and applied the electric brake and the slipper brake. I used the controller as though the car had not got a run back device on; I put the controller handle back to the fifth brake notch and put the reversing handle in the reverse position."

"The current came on again for a brief interval after the car had commenced to run back, and I swung the handles round to put on current, but before I could get current the trolley arm left the overhead wire and was smashed. I then tried the electric brake again, but it had no effect. The wheels of the car were revolving the whole time. I did not try the wheel brake again, as I thought it would cause the wheels to skid."

"I did not signal the conductor to put the slipper brake on at his end. I cannot say where he was when the car began to go back. Nothing checked the car and it gained speed the whole time, and on reaching Bolton Brow it went over."

On car No. 64 the controllers are of the Westinghouse No. 90 type. At one end the controller has the special run-back chain attached, and is known as the "B" style of controller; at the other end the controller was unaltered. To apply the electric brake in case of a run back when the current has left the overhead wire on the "B" style of controller, all that has to be done is to swing the power handle round to the last brake notch, and leave the reversing lever in the forward position. In the unaltered controller the reversing lever has to be pulled backwards to the reverse position, in addition to placing the power handle to the last brake notch. To distinguish the "B" style of controller two letters **B** are painted in white characters about one inch in length on the iron rail of the car in front of the controllers so fitted. The reason why the device has not yet been fitted to the controllers at both ends of No. 64 car is because this car is selected with others to run on the Pye Nest route only, as it has powerful motors, and as there is a very steep rising gradient only on the inward journey, and the cars are always run in one direction, there is no need for the device except on the leading end coming up the gradient.

It takes time to get the cars fitted, as this can only be done when they are brought into the depôt for thorough overhauling, so the cars which run on routes with steep gradients in both directions have been first provided with the device at both ends. This device has been adopted after trials of others of a somewhat similar nature, but which were not entirely satisfactory.

Motorman Simpson is an experienced driver. He was regarded as a first-class man, and worked on the routes with the steepest gradients. He has been a motorman for eight years, and has constantly driven cars with different types of controllers over the Pye Nest route since it was opened for traffic five years ago. He has never had any accident previously. From the returns it appears that he has made 2,280 journeys over this route in the five years, of which 340 were made with the conductor W. Robinson, who was with him on this occasion. But he admits he failed to notice on this occasion the style of controller the car was fitted with at either end, and that he did not use the special device for preventing cars running away backwards, which was fitted to the controller at the leading end of the car, when ascending the gradients, but turned his controller handle and reversing lever to the positions they should have occupied if the controller had been of the unaltered type. If he took this action it follows that there was no electrical braking effect on the car whatever.

The conductor was collecting fares either inside or outside the car (the reports vary), so he could not apply sand at once and help to put on the slipper brake from his end of the car, and the car had acquired considerable speed before he did so.

As electric brakes can be rendered inoperative by the locking of the car wheels, or by a break in the electric connections, or by the breaking of an axle, even if the motorman on a sudden emergency does place the controller handle and reversing lever in the right position (and some accidents have occurred from a mistake being made in this respect), more reliance on steep gradients can be placed on a slipper brake, which can be applied and get its effect independently of the revolution of the car wheels; but it is most desirable that the method of application shall allow of the brake going on instantaneously on an emergency arising, as once a car is out of control it is almost impossible to stop it on a steep gradient, but if the brake can be applied instantaneously the car ought never to get out of control. While cars are on very steep gradients the conductor should be on the rear platform ready at any moment to assist the motorman by applying the slipper brake, and dropping sand as well in case of a car running back. Also, if it is impossible to have only one form of motor equipment, motormen should be employed as far as possible on cars with the same type of controller, as mistakes can so easily be made regarding the position of the controller handle and of the reversing lever, and that motormen should be examined on their cars at uncertain intervals as to the action to be taken on any sudden emergency arising, especially on steep gradients. Also that the curves on steep gradients should be thoroughly cleaned and sanded by men specially appointed for the purpose before the first car goes over the track in the morning, and that the arc lamps in Pye Nest Road should always be

lighted during the dark hours of the day that cars are run over this route.

*

Near **Sunnyside Station (Coatbridge), N.B.R** *On 30th September. Major J. W. Pringle reports that*:—

The 7.50 p.m. special down train, Edinburgh to Glasgow, overtook and ran into a light 6-coupled engine and tender. Both engines were derailed, and considerably damaged, but no other wheels were derailed. The train was crowded with passengers, of whom 44 were injured, and one of them has since died.

The light engine and tender were fitted with the Westinghouse automatic brake and weighed 52 tons 14 cwt. It was running tender first.

The passenger train consisted of a 4-coupled passenger engine (No. 215), 6-wheeled tender (weighing together 78 tons), and 11 coaching vehicles, with the Westinghouse brake working blocks on the coupled engine wheels, the six tender wheels, and 44 out of 60 wheels (double blocked). The total weight of the passenger train unloaded was 213 tons 2 cwt., and it measured outside buffers 445ft. There was some haziness and drizzle, but no difficulty in seeing signals.

Between Greenside and Sunnyside Junctions there are the usual double lines for up and down traffic. At Greenside the main road from Edinburgh on the east (*via* Bathgate and Airdrie) forms a double junction with the Slamannan Branch, which comes in from the north-east. Three double lines unite at Sunnyside—one from Gartsherrie on the north, another from Glasgow on the west, and the third from Bothwell and Hamilton lying to the south.

Greenside Junction signal-box is situated on the north side of the railway lines, about 65 yards east of the junction facing points. From Airdrie South to Sunnyside Junction (about 2,700 yds.), except for 170 yds. east and west of Greenside Junction, where the inclination varies from 1 in 160 to 1 in 380, the average gradient falls at about 1 in 76.

The passenger train approached Greenside Junction from the direction of Airdrie South on an easy left-hand curve. From the Junction facing points to the site of collision the road is straight. Thence forward through Sunnyside Station the lines curve sharply to the right with a radius of 15 chains.

There is a speed restriction of 10 miles an hour through Sunnyside Station and Junction.

On September 30th, the last day of the Glasgow Autumn Holidays, the traffic was exceptionally heavy between Edinburgh and Glasgow. Signalman Adams (Greenside Junction signal-box) at 9.11 p.m. was offered the 7.50 p.m. down express (excursion) train from Edinburgh, from Airdrie South, and he accepted it with the full block signal "Line clear." Having signalled "Line clear" for this express, he lowered the signal authorising the light engine to leave the Engine Shed Road, and move over the crossover from the up on to the down main line, as far as the down starting signal. At 9.12 p.m. the engine was accepted by Sunnyside Junction, and Adams allowed it to proceed by lowering his down starting signal. Immediately afterwards (9.13 p.m.) he received the "entering section" signal for the express. At this moment the down distant and down home signals were at danger, and the down starting signal at "clear." He expected the express to come to a stand at the home signal and turned round to watch for its approach. The express, however, ran past the home signal, and over the junction at high speed. The down starting signal was thrown to danger, but the express ran past this signal also, and collided violently with the light engine as it was moving forward slowly at a spot about 164 yds. in advance of the starting signal.

Pender, who drove the light engine, gives his speed at 7 or 8 miles an hour when the collision occurred. If it be assumed that the whole distance of 164 yds. was traversed at an average speed of 5 or 6 miles an hour only about one minute could have elapsed between the moment when Adams lowered the starting signal for the light engine and the actual collision. From Airdrie South to the site of the collision is about 1¾ miles, and it therefore appears to be doubtful whether Adams' time for the receipt of the "entering section" signal for the express is to be relied upon. It appears to be more probable that the signal was received before the starting signal was lowered for the light engine, and possibly before the light engine was actually accepted by Sunnyside.

However this may be, Adams admits that he broke the Block Regulations when he allowed the down line to be occupied by the light engine after he had accepted the down express at 9.11 p.m. He offers the explanation that it was a very busy day on the line, and that the fireman (McKillop) of the light engine was urging him to get the light engine away as soon as possible. It was anxiety to cause no delay which made him act contrary to the Regulations. The good intention of working the traffic without delay is no excuse for a breach of the Block Regulations, upon which the safety of traffic working primarily depends. As a matter of fact, as the light engine was not booked to leave Hyndland with the special train until 11.15 p.m., and the whole distance from Greenside Junction to Hyndland does not exceed 12 or 13 miles, there was no justification for the representations of urgency which were made to Adams by the engineman. Adams came on duty for 8 hours and had been at work for about 7¼ hours. He was not employed on the 29th September (Sunday). He bears a good character.

Driver Ekevall, with fireman Fawcett, were the enginemen with the 7.50 p.m. down express excursion train, and goods guard Walker was in charge of the train. Ekevall describes the Westinghouse brake as having been in working order when they left Portobello. He used the continuous brake to stop the train at several places between Edinburgh and Saughton West, and again at Westcraigs Station, and found it had its usual stopping effect. In each case the stoppage was due to signals being found at danger. The engine was also watered at Westcraigs, which is about 24 miles from Edinburgh and 11 from Greenside Junction. After leaving Westcraigs no other stop was made. At Airdrie South and Coatdyke Stations all the signals were "clear." The distant signal for Greenside Junction is situated about 200 yds. west of Coatdyke Station, and Ekevall affirms that the signal was also at "clear" when he passed it. He applied his continuous brake, however, by making a reduction of 10 lbs. in the air pressure, in order to reduce speed through Greenside Junction and Sunnyside Station, in accordance with the instructions. On finding that this had no effect in reducing the speed, he made a full application of the continuous brake, and also used sand. This had some effect on the speed, but not sufficient to enable him to stop the train at the home signal for Greenside Junction, which he saw was at danger. He could not, therefore, avoid running by this signal at a speed of 20 or 30 miles an hour.

Locomotive foreman Liddle reports that when the engine of the express was dismantled at Cowlairs after the collision the sand boxes were found to be practically full, and had to be emptied before being taken off the framing. It would appear from this that little sand could have been used on the journey.

The day after the collision the Company's Westinghouse brake inspector reports upon the condition of the continuous brake "fitments" upon the 11 vehicles which, together with engine No. 215, formed the colliding train, and found that a reduction of 10 lbs. from the train pipe set the brake blocks for 10 minutes upon 9 of the vehicles. Upon the tenth (183) the blocks were set, but eased off very quickly owing to an escape of air from one of the piston heads. The blocks were not set at all upon the eleventh vehicle (908), also owing to leakage. With a reduction of 15 to 20 lbs. all blocks were set and remained set for some time. With a train pipe air pressure of 60 lbs., and full application made, all brake blocks were set, and remained set for 15 minutes.

Having regard to this report, and to the proved fact that the continuous brake acted upon the express with its usual effect at Westcraigs Station about 15 minutes before the collision occurred, and also earlier upon the journey, the statement made by driver Ekevall that the brake failed to act effectively between Coatdyke Station and Greenside Junction must be regarded as entirely unsupported. At the most there is a possibility that the braking effort upon two out of the eleven vehicles upon the train was ineffective owing to leakage, and only so when a small reduction of pressure was made. The evidence of fireman Fawcett, the fact that no brake whistle was sounded, etc., negatives the likelihood of the correctness of Ekevall's story that he was using every effort to stop his train.

To demonstrate the effect of the continuous brake under similar conditions of gradient and weight of train to those applicable to the express on the day of the collision, the Company carried out (on 9th Oct.) certain experiments with a train composed of engine No. 213 (of the same class as No. 215) and 12 coaches. Eight of these were six-wheeled, and the remainder four-wheeled vehicles. Four only of the actual vehicles which formed the express at the time of the collision were available for this trial, viz., Nos. 1524, 908, 234 and 1404, and leakages had been repaired. The train ran on the down road between Airdrie South and Greenside Junction, and on each occasion the continuous brake was applied at the distant signal for Greenside Junction. The results of the tests made were as follows:—

1. With 48 wheels braked out of 64, and the brake applied at the speed of 60 miles an hour, the train was brought to a stand in 595 yds.
2. With 36 wheels braked out of 64, at a speed of 63·4 miles an hour, the train was brought to a stand in 903 yds.
3. With 40 wheels braked out of 64, at a speed of 56·2 miles an hour, the train was brought to a stand in 878 yds.

Between the down distant signal and Greenside Junction signal-box the interval is 958 yds.; from the signal-box to the site of the collision the distance is 412 yds.

After the collision the two engines locked together ran a distance of 256 yds. before coming to a stand. For the greater part of this distance eight pairs of engine and tender wheels were off the rails, and bumping over the chairs and ballast. The passenger coaches were separated and the brake pipe parted at five places.

The down distant signal for Greenside Junction was at danger when the excursion train passed it, and if Ekevall had duly observed the warning position of this signal, and had acted upon it, there was ample brake power upon the train for him to have avoided the collision. Having regard to the restriction limiting the speed to ten miles an hour through Sunnyside Station, he was driving rashly and without due consideration to safety, even had he received a "clear" signal on passing the distant and home signal posts. Responsibility for this collision therefore rests upon driver Ekevall and signalman Adams. Driver Ekevall's offence must be regarded as the more serious. Ekevall had been at work about 3½ hours. He had been absent from duty for a fortnight prior to the 30th Sept. on account of a bruised hip, the result of a fall in the engine shed at St. Margarets, and had the authority of his medical attendant to return to duty. There are only 6 entries against his name in the discipline book during the last 14 years.

*

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Contents.

Sir Chas. Scotter, chairman, L. and South Western R., and **Sir Alex. Henderson, Bart.**, chairman, Great Central R., have been elected chairman and deputy-chairman respectively of the Railway Companies' Association for 1908-9.

Mr. Chas. Mortimer, director, Great Western R., has been elected chairman of the Railway Clearing House Corporation, and **Mr. Frank Mansfield** has been appointed secretary of the Railway Clearing House in succession to the late Mr. Harry Smart.

Viscount Churchill, director, has been appointed chairman of the Great Western R. in succession to the late Mr. Baldwin.

Mr. Frederick Green, chairman of the Orient Steam Navigation Co., has been elected a director of the Great Eastern R.

Mr. Richard W. Booth has been elected a director of the Dublin and South Eastern R.

Mr. S. Cooper Chadwick, locomotive running superintendent of the Great Southern and Western R. of Ireland, has been appointed superintendent of the line in succession to the late **Mr. J. H. Bell**. Mr. Chadwick was formerly district locomotive superintendent at Mirfield and at Bolton on the Lancs. and Yorks. R.

Mr. F. G. Randall has been appointed district superintendent of the Great Eastern R. at London in succession to his brother, **Mr. C Randall** who has retired, and **Mr. W. H. Hall** has been appointed district goods manager at Norwich in succession to the late Mr. J. W. Smith.

Mr. F. Audinwood, of the hotel department, Midland R., has been appointed manager of the hotel and refreshment department of the Northern Counties Section of the Midland R. in succession to Mr. F. Cox.

IT is with great regret that we record the death, on the 25th ultimo, at Hastings, of **Mr. Edward Hill**. In railway circles he will be greatly missed, as no one was better known or more popular. He was most ingenious, and was the inventor of a great number of fittings for carriages and wagons, but couplings and either-side brakes had chiefly absorbed his attention of late years. He was a brother of Mr. Vincent Hill, general manager of the South Eastern and Chatham R., and was formerly in the service of the old L. Chatham and Dover R.

*

Conciliation Boards, Great Eastern Railway.

THE first of the Sectional Conciliation Boards, so far as the men's sides are concerned, have been duly elected, and the results of the polling will not, we should think, give unqualified satisfaction to the directors and officials of the Great Eastern R. It may be remembered that Lord Claud Hamilton estimated that very few—5 per cent. if our memory serve us truly—of his company's servants were members of the Amalgamated Society of Railway Servants; but while that estimate may have been correct it is evident from the official figures of the voting issued by the Board of Trade that a large proportion, not to say a majority, prefer to entrust their interests to the men nominated and officially supported by the A.S.R.S. rather than to the other candidates. This is true in all sections except the locomotive, and it is particularly marked in the London district. In other words, the election shows that the non-Union men want the Union men to pull the chestnuts out of the fire for them.

By comparing the list of elected men with the list—apparently incomplete—of men officially recommended in the organ of the society we find that 23 were "run" for the 32 seats, and of these 15 have been elected and 8 defeated, as shown in the following table:—

Department	London	Cambridge	Ipswich	Norwich
Superintendent ...	E E	E E	E E	E D
Goods	E E	E --	-- --	D D
Loco.	D D	— E	-- --	E D
Way and Works	E E	D —	-- --	E D

E = Elected. D = Defeated.

Generally speaking the voting was not close, but the successful candidates were elected by large and in some cases (notably London) by overwhelming majorities.

The success of the A.S.R.S. men in the Superintendent's Department we should think is largely the result of the dismissal of Guard Ambrose, though at Cambridge the nomination of so many non-union candidates for the two seats may have assured their defeat, but the voting was close, much closer than in any of the other sections. There were 10 candidates who polled respectively 418, 414, 409, 238, 215, 106, 98, 68, 60, and 46 votes respectively.

In all the sections the number of spoiled voting papers was much larger than might have been expected from such intelligent men as are generally found in the railway service.

*

The BriCal Adding Machine.

We have had an opportunity of examining and testing the BriCal Adding Machines, which are very ingenious and quite simple to work. They are 6ins. diam. and packed in a case 7ins. square, and are made to add money, weights, or measures. Our illustration shows one for addidng tons, cwt., qrs. and lbs. To work the machine a pointer is inserted in the hole opposite the required number and the disc pulled

round to the right to the end of the slot—that number (of *e.g.* lbs.) will then appear at the lbs. "window" added to the number that was there before. Whether a "long tot" or bundle of invoices could be cast up as quickly with this machine as by a practised clerk is very doubtful, but the machine should be a boon to large numbers who do not take kindly to figures.

*

The Methil Dock, North British Railway.

The main contract for the construction of the new North British R. dock at Methil has been entrusted to Messrs. McAlpine and Sons, Glasgow, who have executed very satisfactorily many important works in Scotland. The contract is a large one, and will involve a sum of over £350,000. The North British R. enterprise in Fife, which is thus inaugurated, will run to about £600,000. Roughly speaking, the dock is to provide a basin of 15½ acres, double the size of the present area, with three quays, enabling the company to berth double the number of steamers of even larger tonnage than they can at present.

The dock is to be constructed to the East of the present one, and it is highly creditable on the part of the engineers that they are able to do this without encroaching on the present siding accommodation at Innerleven. The dock will be between high and low water mark.

The most difficult, if not the largest part of the work, so far as concerns Messrs. McAlpine, will be the construction of the new sea wall, which, as it faces the south-east, will be exposed to the most destructive storms that strike the coast of Fife. This wall is to be carried from Innerleven beach, opposite the church, in a great sweep to about 300ft. from the end of the present East Pier. Inside this area will be formed the new basin, with a depth at high water of 34ft. An entrance channel will be cut through the present sea wall to the new basin. Another noteworthy feature of this dock will be the width of the new gates. There are indications that the work of doubling the railway from Thorton to Leven will be commenced soon.

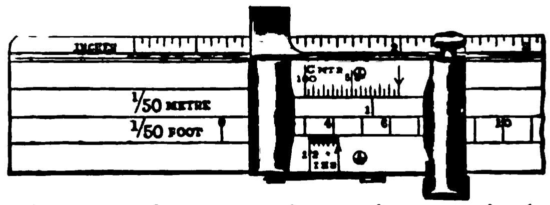
*

Mavitta's Vernier Drawing Scales.

The scales illustrated by the annexed figure have been designed with the object of facilitating accurate mechanical drawing, and after trying them we are able to say that they are particularly pleasant scales to work with.

They are constructed of boxwood and have their edges grooved to take a sliding cursor, which has a device which clamps it in any required position. The clamp is released automatically immediately it is handled with the object of moving it to a new position.

The main divisions are marked on the top face of the boxwood scale as on an open divided scale, and the subdivisions of each main division are carried on the two inside ivory bevels of the slidng cursor, where they are protected from wear, thus enablng a sub-division to be taken at any



point of the scale. The cursor has an index projecting from the front edge and over the plan, thus enabling the measurements read on the top face to be marked direct on to the plan by simply drawing the pencil point against one edge of index. Any two divisions may be marked on the scale, and they may be so arranged as to be used either independently or comparatively. For instance, if the top scale is marked 1/50 size metre the under scale may be 1/50 size foot, thus enabling a comparison to be made between the two at any point.

The scales, which are not expensive, are made by Marvitta, Birmingham.

*

Oldest Railway in Scotland.

The Kilmarnock and Troon R. is said to be the oldest in Scotland, having been incorporated by Act 48 of George III., 1808. It was constructed for the purpose of affording a cheap method of conveying coal from the Duke of Portland's Collieries to Troon. At first the coal wagons were drawn by horses. Passengers were also conveyed by the same method, and a trip in one of these wagons from "Auld Killie" to Troon and back was looked upon as a novelty by the inhabitants of Kilmarnock in much the same way as a trip on an electrical or funicular railway is now loked upon by visitors to certain seaside resorts. The railway was afterwards strengthened to carry steam locomotives. In 1846 it was leased to the Glasgow and South Western R., after which it was reconstructed, and is still worked and maintained by that Company. It was the sixth railway to obtain Parliamentary sanction.

*

Scottish National Exhibition.

In connection with the above named Exhibition, which is to be opened in Edinburgh on the 1st May next, the North British R. Co. will have a temporary station adjoining the Exhibition grounds, and which will be situated on the Corstorphine branch at its junction with the Glasgow

and the North main lines. A platform will be erected on the up-main line with an overhead bridge connecting with the station. Traffic from the west and north will be dealt with at the temporary platform, and from the east all traffic will arrive at the temporary station on the branch line.

*

The Strain of Long Hours.

LORD ALLERTON, at the half-yearly meeting of the Great Northern R., drew attention to the fact that the engine running wages bill showed an increase of £12,897, although the net increase in train mileage was under 1 per cent. This he said was due to several causes, but principally to

> I would not like to call it the Board of Trade interference, but, at any rate, to an effort being made to avoid long hours. I would just like to say on that point that I do not agree with the view which is sometimes expressed in the newspapers, that these long hours constitute a great strain. The fact is they are very often due—and in the majority of instances are due—to a train being blocked and being unable to move. There is no great strain sitting on an engine if it is not working, and I think there is a little too much made on that side; and there is no doubt that having to send men from one district to another to relieve men who have been on an engine ten hours—or, rather, has been blocked for ten hours, which is not quite the same thing as being on the engine te nhours—results, in many cases, in our having to pay the men's lodgings, or pay for them getting back again, all of which is counted in as time; and I understand the estimate is that this has cost us from £7,000 to £10,000 a year. There is a very curious feature about it—namely, that although it is adding to our cost, it is not adding to the earnings of the line.

Delays, mainly caused by collieries, do, of course, occur through blocks of traffic, but there is nevertheless a great deal of loitering which it is difficult to stop, but is known to exist by every locomotive superintendent. Seeing how costly these delays are it might be worth while to try the effect of giving bonuses to drivers who get their trains through. Bonus systems have proved very satisfactory in some of the traffic departments and might work quite as well in the running.

*

New Goods Depot, Glasgow; Caledonian Railway.

ON the Caledonian R. there are several large works on hand now, one of the most important being the erection of a new Goods Depôt on the site of the old poor-house in Parliamentary Road, Glasgow, and which has made remarkable progress of late, and a busy scene, extending over many acres, is witnessed by passengers to and from Buchanan Street Station. An interesting part of the operations is the removal of the huge blocks of stone that have been found while excavating to the north of the demolished poor house buildings. Two new bridges are also being erected at Dobbie's Loan in connection with this work, and it is not unlikely that before the whole scheme is completed a reconstructed station will take the place of the ancient structure that has done duty so long as the Northern Terminus of the Caledonian R. in Buchanan Street.

*

Shrinkage of Wood.

INTERESTING experiments on the shrinkage of wood due to the loss of moisture have recently (says the *American Engineer and Railroad Journal*) been completed by the Forest Service at its timber testing station at Yale University. These experiments show that green wood does not shrink at all in drying until the amount of moisture in it has been reduced to about one-third of the dry weight of the wood. From this point on to the absolutely dry condition, the shrinkage in the area of cross-section of the wood is directly proportional to the amount of moisture removed.

The shrinkage of wood in a direction parallel to the grain is very small; so small in comparison with the shrinkage at right angles to the grain, that in computing the total shrinkage in volume the longitudinal shrinkage may be neglected entirely. The volumetric shrinkage varies with different woods, being about 26 per cent. of the dry volume for the species of eucalyptus known as blue gum, and only about 7 per cent. for red cedar. For hickory, the shrinkage is about 20 per cent. of the dry volume, and for longleaf pine about 15 per cent. In the usual air dry condition from 12 to 15 per cent. of moisture still remains in the wood, so that the shrinkage from the green condition to the air dry condition is only a trifle over half of that from the green to the absolutely dry state.

Books, Papers and Pamphlets.

Locking. Being an elementary treatise on the mechanism in interlocking lever machines, by which the movements of the levers are restricted to certain pre-determined ways, rendering it impossible to operate conflicting switches and signals on railways. By FREDERICK C. LAVARACK. Published by the Author at 114, Park Street, East Orange, N.J., U.S.A. (81 pp., 40 illustrations, with 16 on folding plates. 8¾ins. by 5¾ins.).

This work is submitted by the author for the use of students and those in the shop or on the line that are interested in signalling. It only deals with interlocking and makes no attempt to undertake a consideration of any other branch in the art of signalling. Further, only American practice is referred to. On this account there may not be the field here for its use that there is in America, where signalling is only just emerging out of the clothes of infancy. The training of American railroads is again so varied, and they are not confined to one department but exchange from traffic to engineering and *vice versa* that it behoves all young men to get conversant with every branch. Consequently such a book as this should have a good sale. It is well printed, the arrangement of the position and the shape of the folding plates is very good, and there is an admirable index. The book will probably go into a second edition, and then there are certain typographical points Mr. Lavarack should attend to: The titles of the chapters should be repeated on every other page, the size of the letters of the titles on the illustrations should be uniform—figs. 1, 2 and 3 are all different, figs. 2 and 3 might go on one page, figs. 32 and 37 are the same, and one illustration would suffice, and it would aid a reference to the book were the fig. Nos. of the folding plates repeated outside. These are, however, details which do not affect the good matter in the book and which should have a large sale in America.

*

Transactions, 1906-7: Swindon Engineering Society. Edited by DAVID G. SLATTER, Hon. Sec. Published by the Society, G.W.R. Locomotive and Carriage Dept., Swindon. 1907. [279 pp., 8½ by 5½ and several folding plates; price 10s. 6d.].

This volume contains the following papers and the discussions which followed the reading of them :—*The Work of a Running Department*, by Hy. Simpson; *The Construction of Modern Railway Wagons*, by J. M. Llewellyn; *Stephenson v. Walschaert Valve Gear*, by W. H. Pearce; *Composite Principals and Roofing*, by J. H. Baker; *The Micro-Analysis of Metals, with Examples of its Va ue*, by T. C. Davison, F.C.S.,Wh.Ex.; *Locomotive Cranks and Axles*, by R. L. Burge; *The Equipment of a Running Shed*, by W. A. Stanier, A.M.I.Mech.E.; *Beams, Shafts, Struts and Ties in the Locomotive*, by C. C. Champeney; *The Construction of Steam Rail Motors*, by A. H. Nash; and *The Construction and Maintenance of Motor Omnibuses*, by C. S. Wilson, Stud. Inst.C.E.

It will be seen from the above that the field covered by these papers is wide and varied. Naturally the practice dealt with is chiefly Great Western, but that does not detract from the value of the papers, which are interesting, fully illustrated, and contain much information not readily obtainable elsewhere.

Bulletins of the Engineering Experiment Station of the University of Illinois, Urbana, Ill.

No. 16 briefly presents the results of several years' study of *Trussed Roofs* by N. Clifford Ricker, Professor of Architecture. About 50 trusses of a selected type and of different proportions and arrangement were designed in long leaf pine and steel and changed until the assumed and actual weights of the trusses agreed. Other trusses were likewise designed in white pine and steel and a few entirely constructed of steel. To perform this work as conveniently and as rapidly and accurately as possible, it became necessary to devise simplified formulas and tables, with a systematic method of treatment, all of which are fully explained in the pamphlet. The results illustrated are mostly shown in graphic tables for ready appreciation. The most important features are a new formula for the weights of trusses; per cent. of weight to be added for connections; most economical ratio of depth to span of truss; distance between trusses; number of purlins per panel; and dimensions of panels. It was found that white pine and steel trusses are about 10 per cent. lighter than those of long leaf pine and steel; also, that if carefully designed, steel trusses from 100 to 200ft. span have about the same weight as those of white pine and steel. This bulletin will be valuable to all persons interested in the design and construction of trussed roofs, and copies of it may be obtained gratis upon application to the Director, Engineering Experiment Station, Urbana, Illinois.

No. 17, on *The Weathering of Coal*, by S. W. Parr and N. D. Hamilton, relates to the losses in fuel values which accompany storage under various conditions. The information heretofore available concerning the behaviour of coal in storage is exceedingly meagre. The results of tests, as outlined in this bulletin, add materially to our information and open a way for a better understanding of matters pertaining to weathering, spontaneous combustion, and other difficulties which attend the storage of coal in large masses. Deterioration has been studied with samples maintained in the open air, under cover at varying temperatures, in air tight containers, and in the submerged conditions.

No. 19, on the *Comparative Tests of Carbon, Metallized Carbon and Tantalum Filament Lamps*, by T. H. Amrine, gives a comparative study of the electrical characteristics, life, candle power maintenance, horizontal and vertical distribution and cost of operation of the three most widely used electric lamps under both good and poor conditions of operation. It is based upon a series of tests in which particular attention was paid to obtain exactly similar conditions for the three types of lamps in order to give a fair basis of comparison between types. Comparative rather than absolute results have been striven for, though, in almost all cases, dependable quantative values have been obtained. In an attempt to explain the reason for high efficiency of the newer lamps a study is made of curves plotted between "Filament Temperatures" and "Candle-power per square inch of Filament Area" and between "Watts per Candle-power" and "Filament Temperature." A consideration of these curves leads to the conclusion that the increase in efficiency of the metallized over that of the carbon filament is due almost equally to higher filament temperature and to selective radiation, while for the tantalum filament it is due almost wholly to higher temperatures.

RECEIVED.

Locomotives of 1907. By Chas. S. Lake. London: Percival Marshall and Co., 26-29, Poppin's Court, Fleet Street, E.C. [44pp.; 6¾ins. by 9¾ins.; price 1s. net.]

Boiler Construction, a practical explanation of the best modern methods of boiler construction, from the laying out of the sheets to the completed boiler. By Frank B. Kleinhaus. London: Archibald Constable and Co., Ltd., 10, Orange Street, W.C. 1908. [421pp. and 6 folded plates; 8ins. by 5½ins.; price 12s. 6d.]

Railway Shop up to Date, a reference book of American Railway Shop Practice. Compiled by the editorial staff of the *Railway Master Mechanic*: Maham H. Haig, managing editor; B. W. Benedict, editor. Advisory Committee, C. A. Schroyer, superintendent car department, Chicago and North Western R., M. K. Barnum, mechanical expert, Chicago, Burlington and Quincy R., R. D. Smith, mechanical expert, New York Central Lines. London: Archibald Constable and Co., Ltd., 10, Orange Street, W.C. 1908. [243pp.; 12¼ by 9¼; price 12s. 6d. net.]

Fowler's Electrical Engineer's Pocket Book, 1908. Edited by Wm. H. Fowler, Wh.Sc. M.Inst.C.E., etc. Scientific Publishing Co., Manchester. [670pp.; 6 by 3¾; price 1s. 6d. net.]

The Modern Machine Shop, its Tools, Practice and Design, a practical work dealing with machine shops connected with the leading mechanical manufactures and productive trades. By Rankin Kennedy. Illustrated. Vol. IV. (final). London: The Caxton Publishing Co., Clun House, Surrey Street, Strand, W.C. 1908. [232pp.; 9¾ by 6¾; price 9s. net.]

The Steam Locomotive of the Future. By Lawford H. Fry. Record No. 61. *Locomotives built for the Central Railroad of Brasil.* Record No. 64. The Baldwin Locomotive Works, Philadelphia, Pa., U.S.A.

University of Illinois Bulletins. No. 16. *A Study of Roof Trusses.* By N. Clifford Ricker. [28pp.; 9ins. by 6ins.]. No. 17. *The Weathering of Coal.* By S. W. Parr and N. D. Hamilton. [37pp.; 9ins. by 6ins.]

Gresley's Twin Carriages.

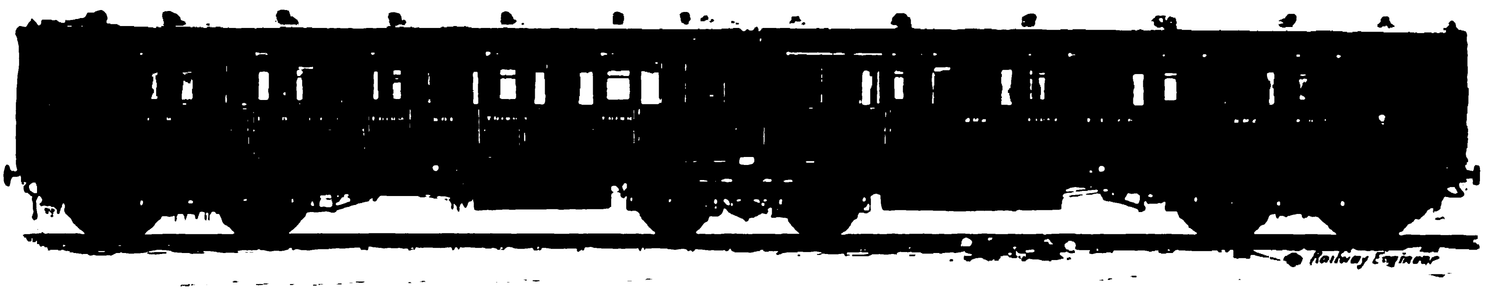
Some railway companies are converting four or six-wheeled carriages into bogie carriages, *e.g.*, the Brighton and S.C. R., by splicing two bodies together, taking out one compartment, and mounting the body on new steel underframes and four-wheeled bogies.

Another means of economising weight and space with carriages is shown by the annexed illustrations of an arrangement patented by Mr. H. N. Gresley, manager of the carriage and wagon department of the Great Northern R. at Doncaster.

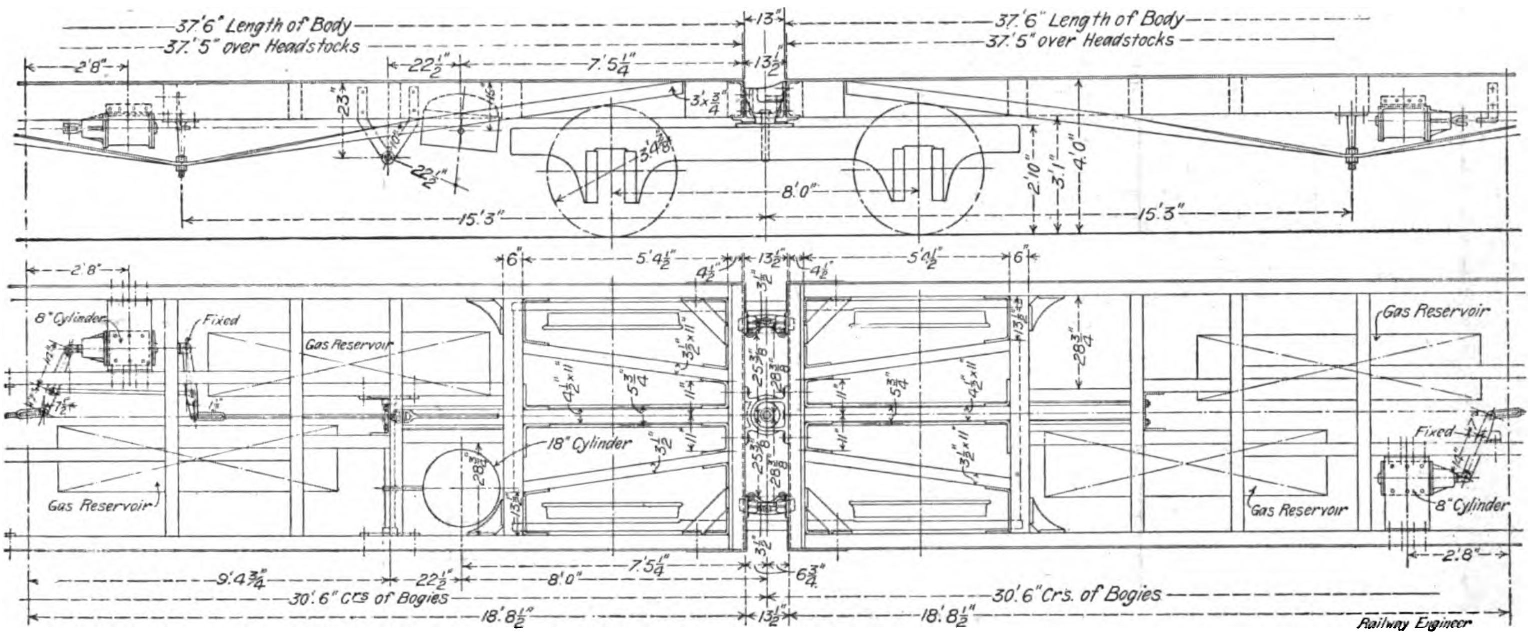
As will be seen, two 6-wheeled carriage bodies are carried on three 4-wheeled bogies, all of the Great Northern R. standard pattern and identical in every respect, except that the side friction blocks of the middle bogie are elongated. The adjoining headstocks of the carriages are stiffened by means of channels on the outside, and to which are fixed the centre castings and the brackets which serve as the top side friction blocks.

Each of the carriages forming the twin is 37ft. 6in. over the body, making the total length, with the space of 1ft. 1in. between the bodies, 76ft. 1in. and 79ft. 5½in. over buffers, and together accommodate 16 first-class and 30 third-class passengers, the total weight of the twin carriage being 37 tons 9 cwts.

The largest 6-wheeled bogie composite E.C.J.S. car-



Twin Carriages (Gresley's System); East Coast Joint Stock.



Gresley's Twin Carriage System.

riages weigh about 36 tons and accommodate 36 passengers, or one ton per passenger, as compared with 16·28 cwts. by the twin-carriage system.

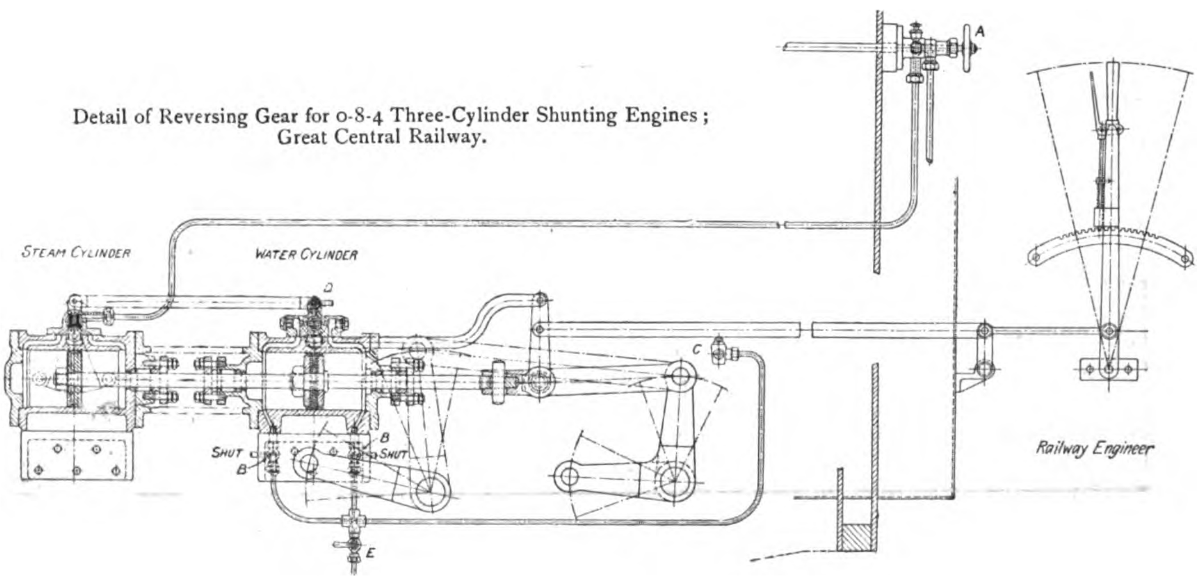
These twin carriages have been running during the past year on the Company's East Coast express service, and we understand are giving every satisfaction.

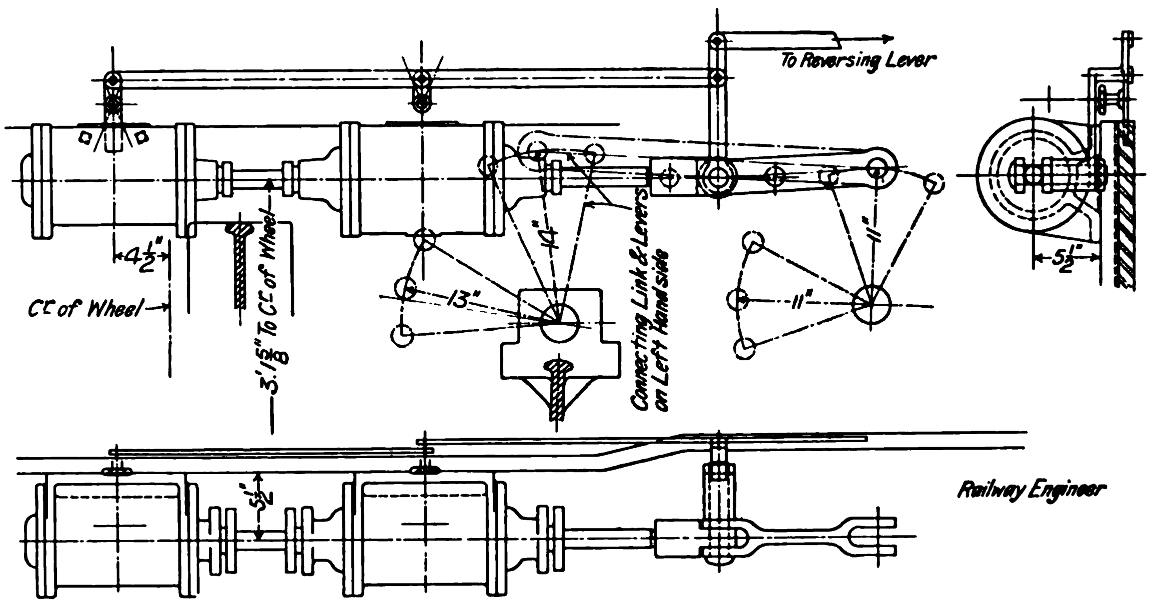
0-8-4 Three-Cylinder Shunting Tank Engines; Great Central Railway.

As promised in our last issue, we publish by the courtesy of Mr. John G. Robinson, M.Inst.C.E., chief mechanical engineer of the Great Central R., sectional drawings of the heavy shunting engines which he has designed especially for working the heavy goods and mineral trains in the new concentration yard at Wath. We also give detail drawings of Mr. Robinson's steam and cataract reversing gear with which these engines are fitted and which enables them to be handled very quickly without throwing a great deal of manual labour on the driver. The steam and cataract cylinders are bolted direct on to the main frame as shown by the detail drawing or on to brackets bolted to the main frame as shown on the general arrangement of the Wath engines. This gear is manipulated from the footplate in the ordinary way by the driver by means of a lever provided with a trigger and notched sector. The steam is taken from a stop-cock. A (provided with a lubricator) on the back plate and which is always fully open when the engine is at work. To charge the cataract cylinder the steam-cock A is closed, the cocks B B and the air valve D are opened, and the reversing lever moved (in either direction) so as to allow the air to escape and the water-valve chamber to be filled with water. When the cylinder is charged the cocks B B and D are closed and the steam-cock A opened. The water supply is obtained from the tank through the cock C, which is always open when the engine is at work. When required the cylinder is drained through the cock E, the cock C then being, of course, closed.

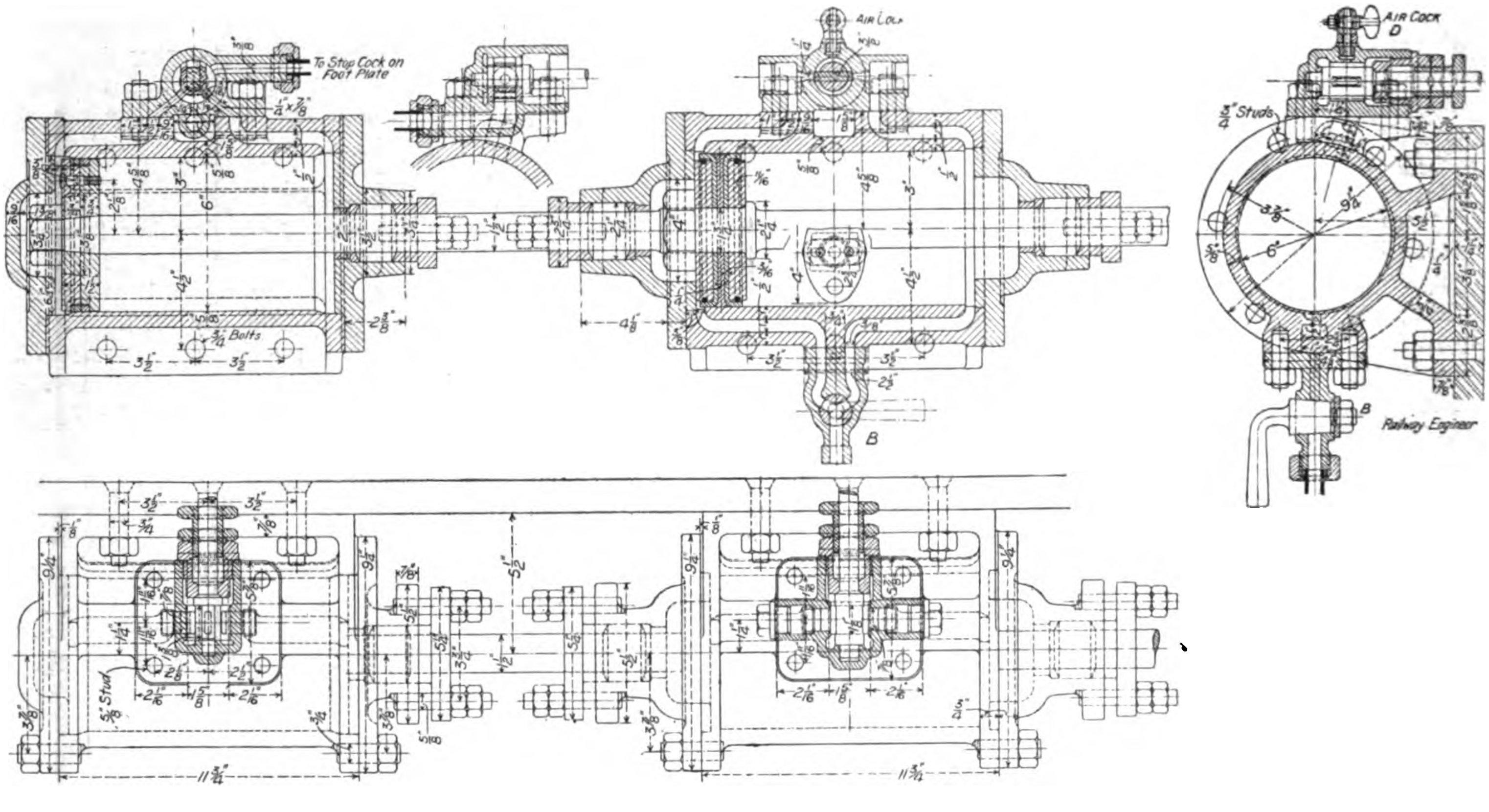
Both the steam valve and the water valve have a rotary movement and are connected by rods directly, as is also the

Detail of Reversing Gear for 0-8-4 Three-Cylinder Shunting Engines; Great Central Railway.





Robinson's Steam and Cataract Reversing Gear.



reversing lever to an arm centred on the cross-head, so that when that lever is moved steam is admitted to one side of the piston and exhausted from the other. Simultaneously the water valve of the cataract cylinder is also opened and allows the water to pass from one side of the piston to the other and the links are raised or lowered by the bell crank levers as shown. When the reversing lever has been moved and locked in the required notch the arm on the cross-head has a new fixed centre on which it swings as the cross-head is moved by the steam piston and as the cross-head moves it into its normal vertical position it pulls (or pushes) the arms on the stems of the steam and water valves and so closes them. and the valve gears are held in the required position.

The principal parts of these engines, viz., the boiler, wheels, axles, axle-boxes and motions are duplicates of other classes of Great Central engines.

The large size of the water tanks, as mentioned in our last issue, have been provided to give the required weight on the wheels.

All the coupled and bogie wheels are provided with a steam brake operated by a valve which works in conjunction with the vacuum automatic brake, with which the engine is also fitted.

The construction of these interesting engines is so clearly shown by the drawings, which are also fully dimensioned, that we do not think we can usefully add to the information we have already given respecting them.

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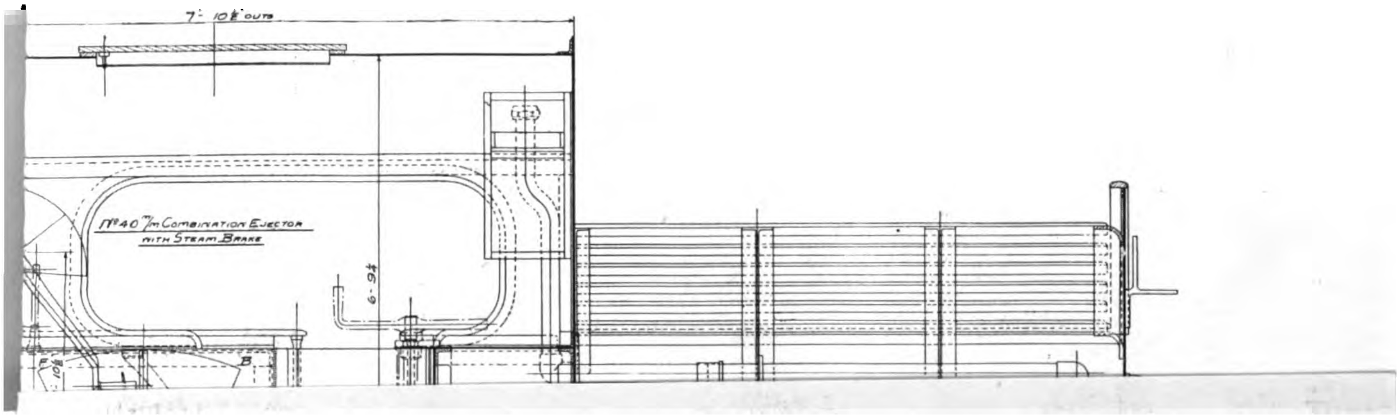

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*The previous articles of this series appeared in the *Railway Engineer* as follows :—I., May 1907 ; II., July, 1907 ; III., September, 1907 ; IV., October, 1907 ; V., December, 1907 ; VI., February, 1908.

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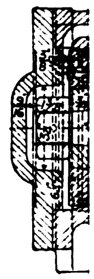

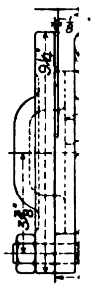

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The principal parts of these engines, viz., the boiler,

we have already given respecting them.

Roofs.—VII.*

In the case of the roof truss shown in figure 44 the line of loads is laid down, and this is simply halved to find the position of point J, since obviously it cannot be in any other place, as all the loads and each of the reactions are symmetrically disposed.

This done, and commencing at the left-hand support, it is seen that the load AB does not affect the roof stresses, so that it is only necessary to set off the stress lines BK and JK from the reaction BJ. Then with load BC and stress BK the stresses CL and KL are set down, and again with load CD and stress CL the stresses DM and LM are easily found.

The next procedure is to draw the stress lines for the other or right-hand side of the roof and we find two points MN vertically one above the other.

Now consider the arrangement at the ridge of the roof, and it is found that the load DE is given together with the stresses DM and EN, and as the resultant of the three forces is MN it is obviously correct to draw the line between these two points to complete the diagram and give the value of the stress in the king-rod of the truss.

The same thing may be shown from a consideration of the stresses at the foot of the vertical rod, where all six stresses are known, and the resultant MN is only required to bring about equilibrium in the seven forces around this point.

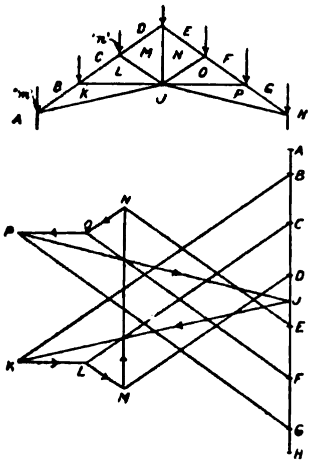

Fig. 44.

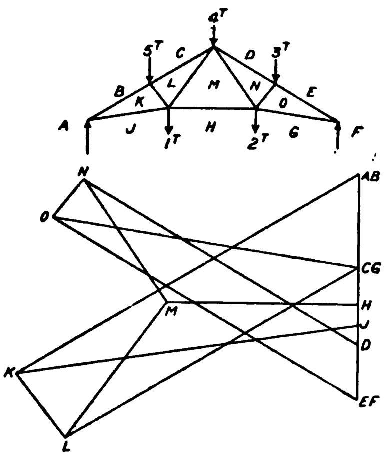

Fig. 45.

From an inspection of the disposition of the bars it is fairly obvious in what sense—tension or compression—all the bars will act, except bar KL and its continuation OP. It seems from consideration that bar KL must act as a strut under load BC, or else the rafter would have to act as a beam and carry the load by transverse resistance between the points "m" and "n."

To decide the matter we place an arrow in the stress line of bar JK, and continuing the system of arrows as shown in the diagram right round the bars to point J again we have no difficulty in perceiving that whilst the arrows on lines JK, MN, and PJ point away from the joint, and are therefore in tension, at the same time the arrows KL, LM, NO, OP point towards the joint and are therefore in compression.

The case shown in figure 45 is more complicated than the last, and the loading is not symmetrical, being made up of three unequal loads at the different points of the roof, and also of two unequal hanging loads suspended from the tie rod as shown in the outline diagram of the roof principle.

Of course the first thing to do is to find the values of the two reactions at the points of support, and this can be done either by the use of a funicular polygon and closing line, or by the simple summation of the leverages of the various loads, and the latter method is adopted, as follows, for the left-hand support :—

$$3 \times \tfrac{1}{4} + 2 \times \tfrac{1}{3} + 4 \times \tfrac{1}{2} + 1 \times \tfrac{2}{3} + 5 \times \tfrac{3}{4} = 7{\cdot}83 \text{ tons}$$

and for the right-hand support :—

$$5 \times \tfrac{1}{4} + 1 \times \tfrac{1}{3} + 4 \times \tfrac{1}{2} + 2 \times \tfrac{2}{3} + 3 \times \tfrac{3}{4} = 7{\cdot}17 \text{ tons}$$

$$\text{total, } 5 + 4 + 3 + 1 + 2 = 15 \text{ tons.}$$

The load line is now laid down in the usual way for the external loads BC, CD, EF, but it will be seen that when the two reactions are set down on the load line, that is, AJ from the top and FG from the bottom, that they overlap, and that the load and reaction line now becomes complicated to some extent.

That the five loads with the reactions are laid down in this manner instead of in one continuous line is a matter of convenience only, and to avoid confusion both in the notation and in the working out of the stresses.

By laying down the letters in proper sequence we set off upwards the hanging load JH over the reaction line AJ, and from the reaction line FG we set off downwards the hanging load GH, the point H found in this way from each of the reaction lines being of course superposed, otherwise the loads and reactions are incorrectly drawn.

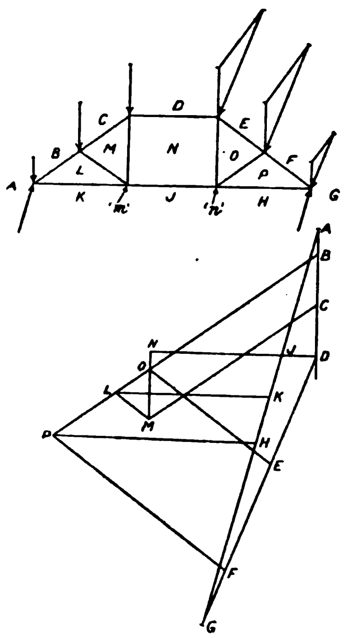

Fig. 46.

From the reaction AJ, stress lines are now drawn as AK and JK, and with stress AK and load BC (the letters A and B being superposed) the resultant CK is given, which is resolved into KL and CL.

Taking now the joint "m" there is the load HJ and the stresses JK and KL already known, producing the resultant HL, which is resolved along HM and LM parallel to the corresponding bars in the truss diagram.

The other half of the stress diagram is drawn in exactly the same way as that just described, and of course the point M found from both sides should coincide.

The case shown in fig. 46 is also of some complexity and consists of an ordinary queen post roof truss with external loads, vertical on one side of the roof and inclined on the other, together with two vertical loads suspended from the horizontal tie rod or beam of the roof. For the sake of simplicity the case of the external loading is dealt with first.

The load line is set down as shown at AB, BC, CD, DE, EF, FG, and the resultant is drawn from A to G. The point of division of the two reactions may be found by the funicular polygon and closing line, or in a much simpler manner by drawing the stress lines BP (which is an extension of BL)

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and FP, and then if a horizontal line is drawn from P the point H is found on the load line resultant AG

The point H being found in this way, it is an easy thing to commence at the right hand, and from the point P already found, the load EF and stress FP being known, the resultant EP is at once resolved into EO and PO, while from the stress EO and load ED, resultant DO, the stresses DN and ON are set down.

The line DN cuts through the line AG, and this gives the point J. The next procedure is with stress DN and load DC known, resultant CN, to resolve this along CM and NM. Then with CM and CB known, resultant BM, draw ML and BL, the latter being superposed on BP already drawn.

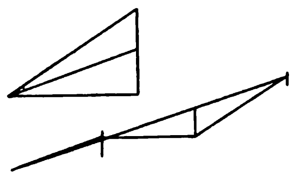


Fig. 47.

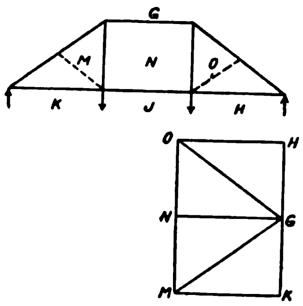


Fig. 48.

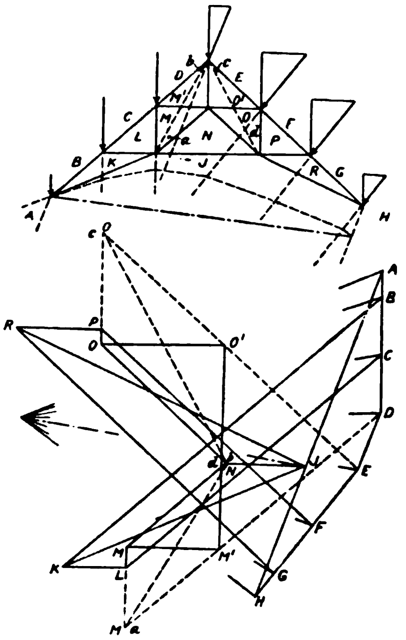


Fig. 49.

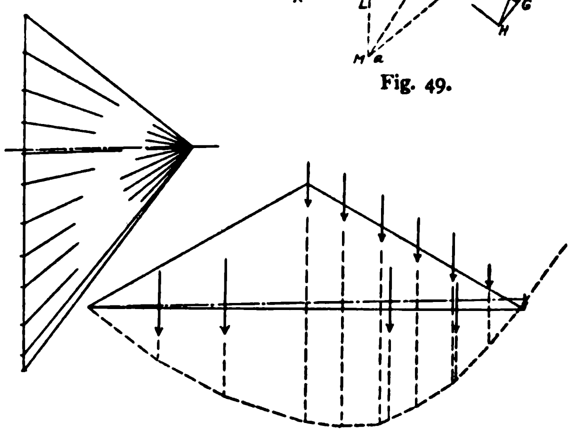


Fig. B.

For the bars at the foot of the rafter on the left-hand side we have the stress BL and the load AB known, with resultant AL, which can be resolved into AK and LK, and this completes the stress diagram for the external loads.

Now consider joint "m," and it is found that although we have the stresses JN, NM, ML, LK, there still remains a force JK not yet provided against, and at the joint "n," although we have the stresses HP, PO, ON, NJ, yet there remains a force HJ not introduced.

This is the effect of the design of the roof, which is not composed of a series of triangles, is therefore not self-contained, and will collapse unless the two stresses HJ and JK are provided for.

The force HJ is downwards and the force JK is upwards and will produce reactions as shown in fig. 47, and the resistance will have to be provided by the transverse strength of the beam.

The stresses for the two suspended loads are now obtained as shown in fig. 48. The two reactions in this case equal the two loads and are set down in the stress diagram as GH and GK. The reaction GH is resolved along GO and HO, and stress GO is in turn resolved into GN and ON. The other half of the diagram is constructed in the same way.

The stresses for the two conditions of loading, external

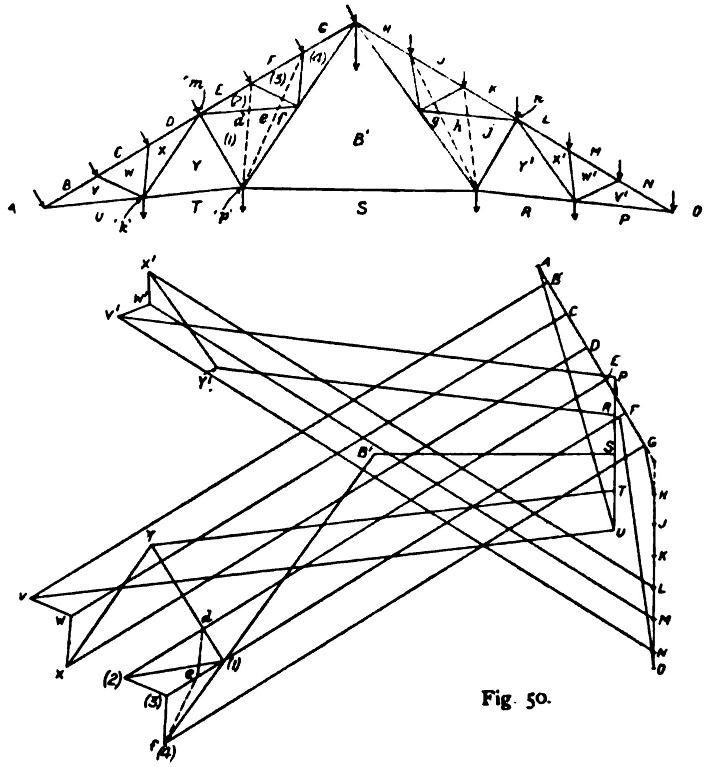


Fig. 50.

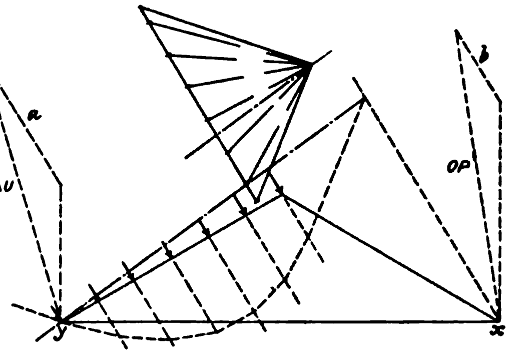


Fig. A.

and hanging, are now summated, and the roof timbers, rods, and bars made to suit.

The next form of roof truss to be considered is shown in fig. 49. Following the usual procedure, the line of loads is laid down as given in the stress diagram, and by means of a funicular polygon the two reactions AJ and JH are found upon the assumption that each of the two bearings is able to withstand inclined loads, or, in other words, that the supports are fixed.

Starting from B and J, and drawing lines parallel to the bars in the outline diagram above, we obtain the values of BK and JK. Next, with the stress BK and the load BC known, and forming a resultant KC, the stresses CL and KL are easily found.

At this point the difficulty occurs that at the next joint

there are two forces to resolve into three, which is of course impossible. If, however, the bars MM^1 and MN are assumed to be removed and bars ab and cd are allowed to be inserted, as shown by dotted lines in the outline diagram, the stresses in the remaining bars around the upper joint can be found by taking the stress CL and the load CD, resultant LD, and resolving this into LM and DM.

Turning next to the lower joint at the foot of the vertical tie bar LM, we have the stresses JK, KL, and LM, forming a resultant JM, or what is identical, Ja, from which the stresses ab and Jb are found, the stress Jb being of course the same as JN in the completed diagram.

Now, proceeding with the bars on the other side of the roof truss, we have GR and JR easily found, and with stress GR and load GF the resultant FR is transformed into RP and FP parallel to the bars in the outline truss above. Then with OO^1 and ON out and replaced by the temporary bar cd we have the known stress FP and given load EF with resultant EP to translate into the two stresses EO and PO.

Now turning to the joint at the foot of the vertical rod OP we have the three known stresses JR, RP and PO, leaving a resultant JO, which is in its turn resolved into Jd and cd, of course Jd being again identical with JN.

The value of the stress JN being thus discovered for both sides of the roof truss, we can replace the letters "b" and "d" in the stress diagram with the letter N, and if the temporary bars ab and cd are deleted and the permanent bars MM^1, OO^1, MN, NO replaced, we can again consider the joint at the foot of the vertical post LM.

Here then there are the stresses given in JK, KL and JN, with resultant LN, and this is resolved into LM and MN, showing clearly that with the permanent bars the stress in the vertical rod LM is very different to what it was with the temporary bar ab in position.

Taking the joint at the foot of the other vertical rod OP, the stresses JR, RP and JN give the resultant NP, which may be resolved into PO and NO.

The joint at the top of the vertical bar LM may next be taken. We have the stresses CL, LM and the load CD, with resultant DM, to resolve into DM^1 and MM^1, and at the top of the vertical bar PO we have the stresses FP, PO, and the load FE, with resultant EO, to resolve into EO^1 and OO^1.

With these found, the apex joint is found to have stresses EO^1 and DM^1 and the load DE, which only require the line O^1M^1 to complete the bars at the joint, and if we work the other way from the foot of the central rod we have the known inclined stresses ON and NM, together with the horizontal stresses OO^1 and MM^1, which again only require the vertical O^1M^1 to complete the figure.

In the case of the roof principal shown in fig. 50, etc., a complication arises from the fact that there are extra hanging loads to be considered additional to those produced by the roof covering and the wind. The distribution of loads provided for is that of inclined loads at each of the purlins of the roof on the left-hand side, vertical loads only on the right-hand side, and the additional five hanging loads already referred to. The bearngs are assumed to be fixed at both ends of the roof truss.

The first thing to do is to find the values of the reactions from these systems of loads, fig. **A** being the diagram for the inclined loads, and fig. **B** the diagram for the vertical loads. The line of loads, funicular polygon, and closing line being used for this purpose in both of the diagrams in the usual way. The values of the two vertical reactions for the vertical loads are then superposed on the two inclined reactions in diagram **A** to obtain the combined reaction AU and OP at "y" and "x."

These two reactions thus being found, the line of loads may now be laid down as in fig. 50, where the inclined and vertical external loads, being set down from A to O, the two reactions OP and AU are drawn upwards and downwards from the extremities of this line, and P and U are joined by the four extra loads, PR, RS, ST and TU.

Commencing now at the left-hand of the roof principal and working from B and Ú, the stresses in BV and UV are laid down. With line BV and load BC the reaction CV is found, which may be transferred to the lines VW and CW. Next, with stress CW and load CD, reaction DW, the lines WX and DX are found without difficulty.

Considering now the first joint from the left-hand "k," we have already known the load TJ, and the stresses UV, VW, WX, with reaction XT, which may be resolved into the two directions XY and YT.

The next joint "m" at the upper part of bar XY now presents the "crux" of the diagram, the difficulty being that although we know the load DE and the stresses DX, XY, the resultant of the three known forces has to be resolved into three directions, which is of course impossible to solve as the question stands. Hence, for the solution, the next three bars between this joint "m" and the ridge of the roof are temporarily removed and replaced by the two temporary bars de, ef on this side of the roof and gh, hj on the other side, when the three corresponding bars on this side of the roof, between the ridge and "n," are temporarily removed.

Working, therefore, on this assumption for the joint "m," we have the load ED, and the stresses DX and XY, with resultant EY, which may be at once resolved into Ed and dY. Going up to the ridge to the next joint we have the load FE and the stress Ed, with resultant Fd, to be transferred into the stresses Fe and de, and further up the back of the principal the load GF and the stress Fe, resultant Ge, to be resolved into ef and Gf, the latter stress Gf being asumed to be the permanent stress when the inner bars are removed and replaced.

The joint "p" is now to be considered, and at this point we have the load ST and the stresses TY, Yd, de, ef, which together form a resultant Sf which is at once resolved into fB^1 and SB^1.

At this juncture we remove the temporary bars and replace the permanent bars, and, still working at joint "p," we have obviously stress B^1S, load ST, and stress Y(1), which only requires the line superposing from (1) to B^1 to complete the stresses at the point "p."

Now for the joint "m" the stress (1)Y has just been found, we have the other stresses YX, XD, and the load DE, with the resultant (1)E, to resolve into the stresses (1)(2) and E(2). For the next joint up the rafter there is the load FE and the stress E(2), to form a resultant F(2), which may be resolved into the two directions (2)(3) and F(3). Again, for the next higher purlin we have the load GF and the stress F(3), with resultant G(3), to transpose into (3) (4) and G(4), the latter stress G(4) being identical with Af, which is already found.

The stresses for the other half of the roof are to be found in precisely the same way, and an indication of some of these stresses is given in the stress diagram.

(To be continued.)

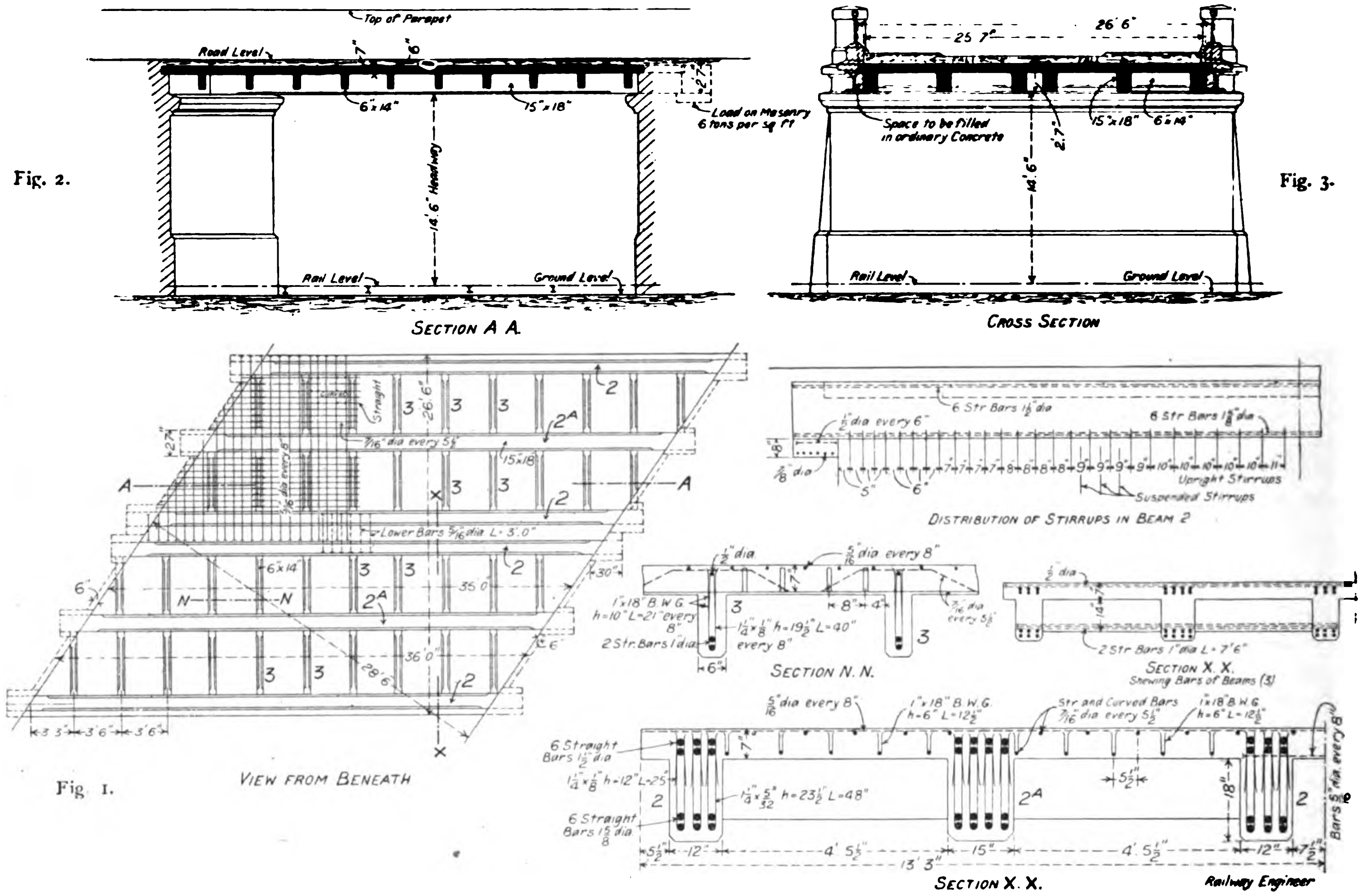
Ferro-Concrete Overbridge; North Eastern Railway.

Having erected office buildings, warehouses, and a large goods station in Newcastle-on-Tyne of Ferro-Concrete, the engineers of the North Eastern R. have gone a step further and applied the Mouchel-Hennebique system of Ferro-Concrete to bridge design as an economical and imperishable substitute for steelwork, which, unless carefully protected, is rapidly destroyed by atmospheric influences, and the corrosive gases and steam discharged from the funnels and safety valves of locomotive engines.

The destruction of iron and steel bridges is so extensive in the United States that they are being replaced on a large scale by structures of Ferro-Concrete, which is quite unaffected by deleterious gases and climatic variations, and, unlike iron and steel, involves no expenditure for painting.

The new Ferro-Concrete span has been built upon the abutments which previously carried a bridge consisting of cast-iron girders, between which were cambered cast-iron plates and earth filling. One of these girders was found to have been fractured, either as the result of flaws in the metal, or excessive loads. Consequently it became necessary to re-construct the bridge, but as the abutments were in good condition they were allowed to remain as the supports for the Ferro-Concrete girder span.

Referring to figs. 2 and 3, it will be observed that the decking consists of a continuous slab of Ferro-Concrete, 6in. thick, laid over a system of longitudinal and transverse beams, the former 12in. wide by 18in. deep and the latter 6in. wide by 14in. deep, but the effective depth in each case is really increased by 6in., the thickness of the deck slab.



Ferro-Concrete Overbridge ; North-Eastern Railway.

On the Great Western R. the erection of several Ferro-Concrete bridges in the city and environs of Bristol has been commenced, and on the Great Eastern R. an overbridge of reinforced concrete is about to be built, but to the North Eastern R. must be given the credit of having completed the first bridge in Great Britain.

This bridge is illustrated by the annexed drawings, and is situated in the parish of Nidd Bridge, about 5 miles north of Harrogate. It was designed for carrying the heavy road traffic on the Brearton and Ripley Highway across the Leeds Northern branch of the North Eastern system.

From figs. 1 and 2 it will be seen that the bridge comprises six Ferro-Concrete girders which have a span of 35ft. clear between the masonry abutments, and that the width between parapets is 25ft. 7in.

The main beams are disposed in two groups of three, this arrangement having been made in order to facilitate the construction of the bridge in two longitudinal sections, thereby avoiding the interruption of highway traffic.

The main and secondary beams are strongly reinforced by ordinary round steel bars for resisting tensile stresses due to bending moments and also by vertical stirrups or loops of steel strip for withstanding shearing stress and tension on diagonal planes in the concrete. The secondary beams constitute short continuous girders, and the reinforcing bars are disposed with a special view to the distribution of internal stress prevailing in members of that class. The concrete in the deck slab is reinforced in longitudinal and transverse directions by round steel rods as well as by stirrups for resistance to shearing stresses, and in addition to the con-

tinuity between the reinforcing system the whole of the construction is of monolithic character.

It was not found necessary to disturb the existing parapets and the cast-iron girders supporting them, as the whole of the load coming on the Bridge is now supported by the Ferro-Concrete superstructure.

This bridge was designed to bear without undue deflection or vibration the rolling load of a 20-ton traction engine placed in the most unfavourable position and the area not covered by the engine to be also subjected to a live load of 1 cwt. per sq. foot.

The designs were prepared by Mr. H. J. Rudgard, Assoc.M.I.C.E., under the supervision of Mr. W. J. Cudworth, M.Inst.C.E., engineer of the southern division of the North Eastern R., under whose superintendence the work was executed by the Yorkshire Hennebique Contracting Co., Ltd., of Kirkstall Road, Leeds, a firm which has built a good number of Ferro-Concrete highway bridges in various parts of Yorkshire and other counties.

One half of the bridge was commenced on September 24th last year and completed on the 9th of October. The second half was started on November 4th and finished on the 19th of the following month. These dates show in a striking manner the rapidity with which Ferro-Concrete work can be executed. The first section of the bridge having been completed in the short time of 15 days, was left to harden for nearly a month. At the expiration of that period it was opened to traffic, and the second section being then taken in hand, was also completed in 15 days. Of course steel girders could have been erected on the site in much less time, but the length of time consumed in obtaining delivery of the finished steelwork is quite another matter.

On January 17th the bridge was officially tested by the railway company's engineers, accompanied by Mr. Joseph H. Halstead, surveyor to the Knaresborough R.D.C.; Mr. T. J. Gueritte, B.Sc., representing Messrs. L. G. Mouchel and Partners; and Mr. H. Fisher, representing the Yorkshire Hennebique Contracting Co., Ltd., the contractors. As no 20-ton steam roller could be found in the district the engineers decided to conduct the tests with a 14-ton steam roller, which was passed several times across the bridge.

The maximum deflection of the main girders in no case reached $\frac{3}{32}$ in., and therefore was less than .00022 of the span. This deflection is exceedingly small, and far less than the minimum permitted in the case of steel girder spans. If a 20-ton steam roller had been available it is probable that the deflection would not have exceeded .00031 of the span.

These tests must be regarded as demonstrating in a most satisfactory manner the exceptional elastic strength of Ferro-Concrete and the suitability of the material for railway and highway bridge construction.

Block-Signal Systems and Appliances for the Automatic Control of Railway Trains in the U.S. America.

In the *Railway Engineer* for June last appeared a summary of the report on above subject that was presented by the Interstate Commerce Commission to Congress. It was therein stated that Congress had voted 50,000 dols. for experimenting with systems of automatic train control.

Subsequently a block-signal and train control board of four experts and a secretary was appointed to examine ideas submitted to the Commission and to make experiments. From the annual report of the Interstate Commerce Commission we learn that up to the issue of the report 495 devices or systems had been inspected, of which 245 had been rejected on the grounds that, whilst they were "safety appliances," they were not related to signalling. Of the remaining 250 ideas a complete description had been furnished of 175. Already 55 of these had been rejected, mostly because they had not sufficient merit to warrant further attention. As was expected, "the inventors are manifestly unacquainted with the requirements of railroad service." Of the 120 devices under examination the report says that it is expected that a number will exhibit sufficient merit to warrant installation and test, but as it is desirable that such tests as may be undertaken shall extend over a considerable period of time in order to determine the efficiency of the devices under all conditions of traffic and weather likely to be encountered in practical service, it will necessarily be several months before a final report can be expected.

The report also says that it is desirable to inspect certain cab signal installations in Europe, some of which are of 10 years' standing. Cab signals, it is remarked, are not automatic train stops, but they use either the mechanical trip or electrical contact in the same way that an automatic stop would use it. It has therefore been considered advisable for a member of the Signal Board to visit England and France to examine this European experience.

Capt. Angel Ames, the signal engineer of the electrical zone of the New York Central, and Mr. B. B. Adams, one of the experts employed by the Commission to make the report reviewed in the *Railway Engineer* for June last, are two members of the Signal Board, and they arrived in England on the 5th ultimo.

Boring Multiple Cylinders.

By E. J. McKernan, *Tool Expert, Atchison, Topeka and Santa Fe Railway System.*

The usual locomotive cylinder boring machine consists of a horizontal spindle and table permitting of no adjustment at all or only lateral adjustment. With these machines of the old design much time is consumed in properly setting the cylinder so that the boring bar will strike the true centre; and high speeds and rapid cutting are not obtained. These disadvantages are, of course, magnified when cylinder castings having two or more cylindrical chambers are to be bored and faced, because the work has to be set twice, and the cylinders and valve chambers (for piston valves) must be truely parallel with each other. If the cylinders should be out of parallel the working of the engine will throw great strain upon the guides with consequent detrimental effect on the locomotive machinery, causing undue wear, strain and trouble.

With the development of high-speed steel for cutting tools of great capacity, and in locomotive construction, with engines having piston valves and often compound cylinders on the Vauclain principle or on the four cylinder balanced compound principle, a machine capable of the most effective service under these conditions is a shop necessity, and on the single bar machine has been found to be the best for general railway practice. It has less gearing and is simpler and, consequently, much easier to maintain. On account of the lesser number of parts, the single bar machine is the most economical to drive, hence the power required can be obtained from a small motor. There are no doubt some advantages in boring two or three chambers at once, but it has been found in practice that the chatter of one tool is transmitted to the other tools, thereby causing a rough finish in all bores. This is entirely obviated in the single bar machine.

At the Topeka shops of the Santa Fe R. a cylinder boring machine which will answer all requirements in regard to the boring of cylinders for all classes of compound engines has been built. This machine is also adapted to bore cylinders

on engines which have one cylinder or chamber at an angle to the others. All cylinders or chambers may be bored at one clamping of the casting by raising or lowering the table which has an elevating movement of 37in., a cross travel of 35in. and a range of 15° (fig. 1), horizontal swivelling as shown by figs. 1, 2 and 3. The mill is direct motor driven. The table is raised or lowered by power connection with the main motor through bevelled gears and clutches, controlled from the operator's side of the machine. All the mechanism is of the latest design and is strong and durable, all gears

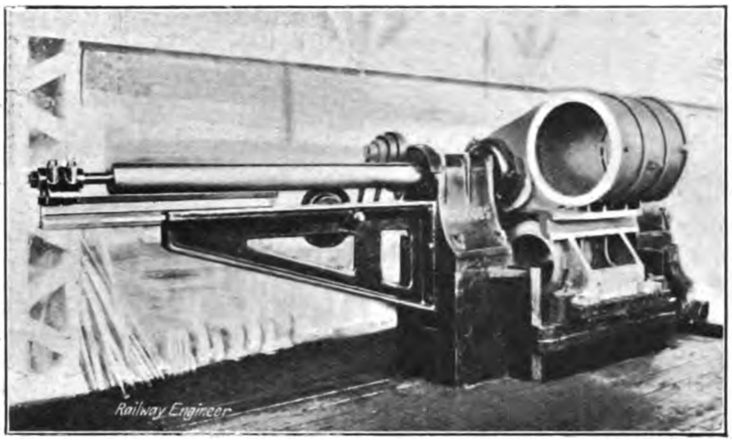


Fig. 1.—Rapid Universal Locomotive Cylinder Boring Machine.

being made from good gray iron, all bushings of phosphor bronze; the boring bar is 7in. in diam. and is made from open hearth steel, and is fed through the cylinder by means of a spur gear and rack which makes it very rigid in operation and gives a very smooth bore.

One of the facing heads on the machine is made so that it will move along on the bar and is driven by means of a 1in. key and set screw, and will pull any cut that is put on the machine. The facing heads are fed by means of a star feed attachment.

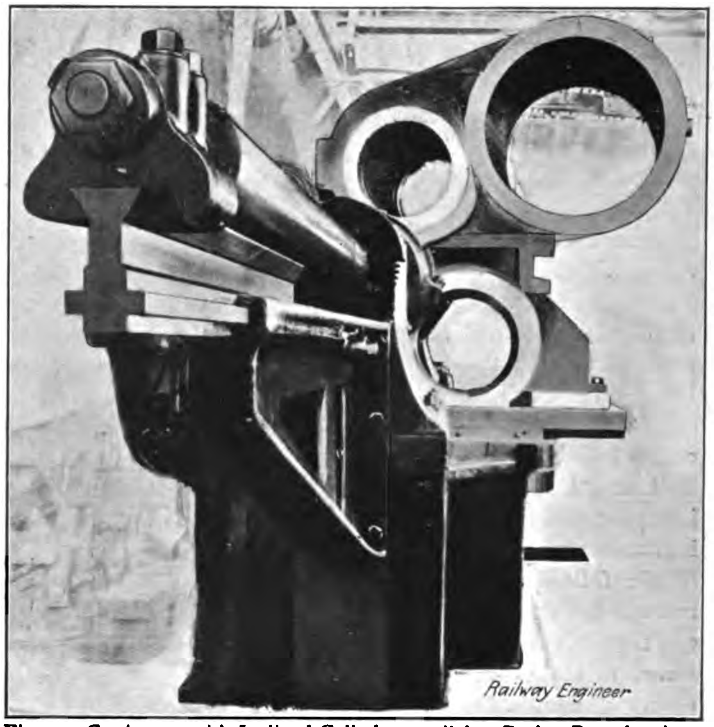


Fig. 3.—Casting set with Inclined Cylinder parallel to Boring Bar, showing Low Pressure Cylinder and Valve Chamber out of parallel.

The screws that elevate the table are made from soft steel and are $5\frac{1}{2}$in. diam. and are $\frac{3}{4}$in. pitch, the screws set at right angles to the boring bar.

The total weight is about 15 tons, and the machine takes up floor space of 223 sq. ft., having an extreme length of 21 ft. and an overall range in width of 14 ft.

This machine is capable of boring a three chamber compound cylinder in 15 hours or in a year of 3,000 working-hours 200 three chamber compound cylinders.

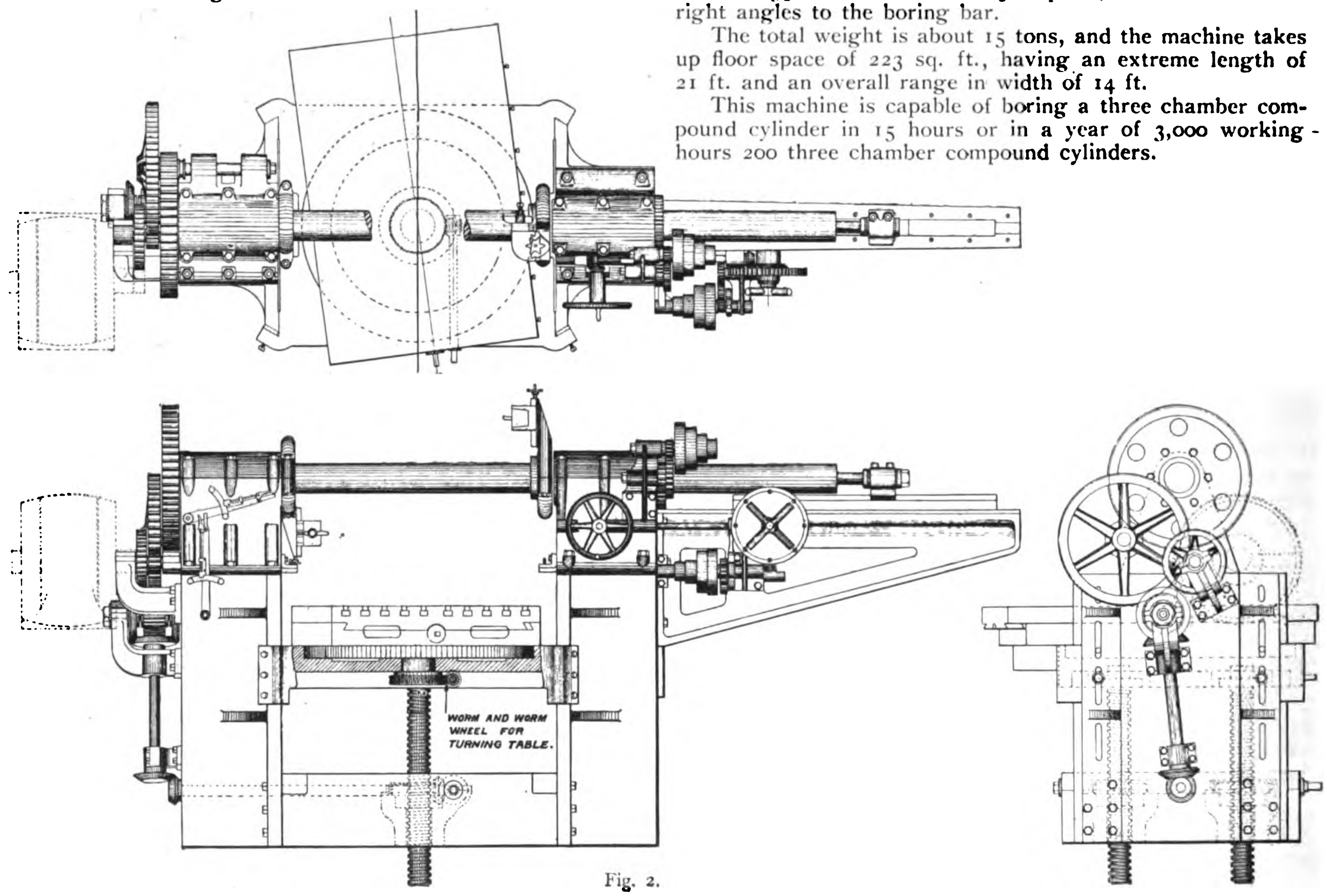


Fig. 2.

On the old style boring mill it has taken from 26 to 28 hours to bore a three chamber compound cylinder. It will be noted that by the use of a modern boring mill of this kind 11 hours can be saved on each three chamber compound cylinder.

A simple cylinder can now be bored in three hours on this machine, thus making a saving of 5 hours on each simple cylinder bored, or over 1,500 dols. per year in wages alone, in addition to increasing the machine capacity from only 375 cylinders per year to 1,000 simple cylinders, giving an output of 625 cylinders more per year. Where only 115 three chamber compound cylinders could be handled with the old style boring mill, the new machine will bore 200 cylinders, thus increasing the output of compound cylinders about 77%.

If a machine which bores only one chamber of a locomotive cylinder casting at one time is to compete successfully with one which can bore three chambers simultaneously it must not only bore rapidly but it must be so constructed so that only one setting will be required to bring the chambers into position to bore. This arrangement has been attained in the machine described in this paper insuring that after a cylinder has been lined up and clamped on the table any of the chambers may be brought exactly into position for boring and making it impossible to bore two chambers out of parallel unless desired.

A machine of this design has been in operation for some time at the Topeka shops of the Atchison, Topeka and Santa Fe R. Company, and is giving first class satisfaction, both in its convenience in handling, and in the lower production cost. It is understood that arrangements have been made for the Tool and Railway Speciality Manufacturing Company of Atchison, Kansas, to place machines of this type on the market.

The Erection of the Pwll-y-Pant Viaduct, Barry Railway.*

The viaduct described is on the Brecon and Merthyr Extension of the Barry R. It is for a double line of railway, is 800 yards in length, and crosses the main line of the Rhymney R., the Rhymney Valley and river, about 10 miles north of Cardiff. It consists of eleven spans of steel lattice-girders, each 170ft. 11in. long, which rest on brick abutments, and ten intermediate piers, eight of these piers being over 100ft. in height; and the viaduct terminates at its north and south ends with semi-circular brick arches of 36ft. span.

The nature of the foundations, the concrete and brickwork in the abutments, piers, and arches, and the steelwork of the girders, cross girders, decking and bearings having been referred to, the author describes the timber staging on which the girders forming three of the spans were erected and riveted, and then calls attention to the chief feature of interest in the work, namely, the special method adopted for the lifting, carrying forward, and subsequent launching of the girders of eight of the spans on to the piers in advance of those already erected.

With a viaduct such as that described, ½ mile in length, and over 100ft. in height above the valley and river which it crosses, the time required and the cost of erecting a staging from the ground-level for eleven spans would have been excessive; whereas the method described in this paper, besides proving very successful in its execution, was economical both in time and in cost. The author believes this to be the first instance in England of the erection of girders of such dimensions and weights by the method here described. Details of the weights of the girders and flooring, as well as of the rolling loads employed in testing the viaduct, are given, and also particulars of the progress of the brickwork, and of the erection, riveting and launching of the girders, the number of men employed, and the total cost.

* **Abstract of a paper by Mr. A. L. Dickie read before the Institution of Civil Engineers.**

The Locomotive from Cleaning to Driving.—XV.*

By
John Williams, *Locomotive Inspector Great Central R.*, and
Jas. T. Hodgson, *Mechanical Superintendent School of Technology, Manchester.*

Lubrication.

The Hulburd Engineering Co., London, are makers of the "sight feed" lubricator, as shown in the sectional drawing, fig. 46.

These lubricators are made in a compact manner and are fixed inside the cab, so that the driver by watching the drops of oil as they rise through the sight glass has the satisfaction of seeing the lubricant actually fed at any desired rate into the pipes leading to the parts to be lubricated. With this type of lubricator the feed of oil is regulated by "equalisers," which prevent too great a variation in the feed supply, and

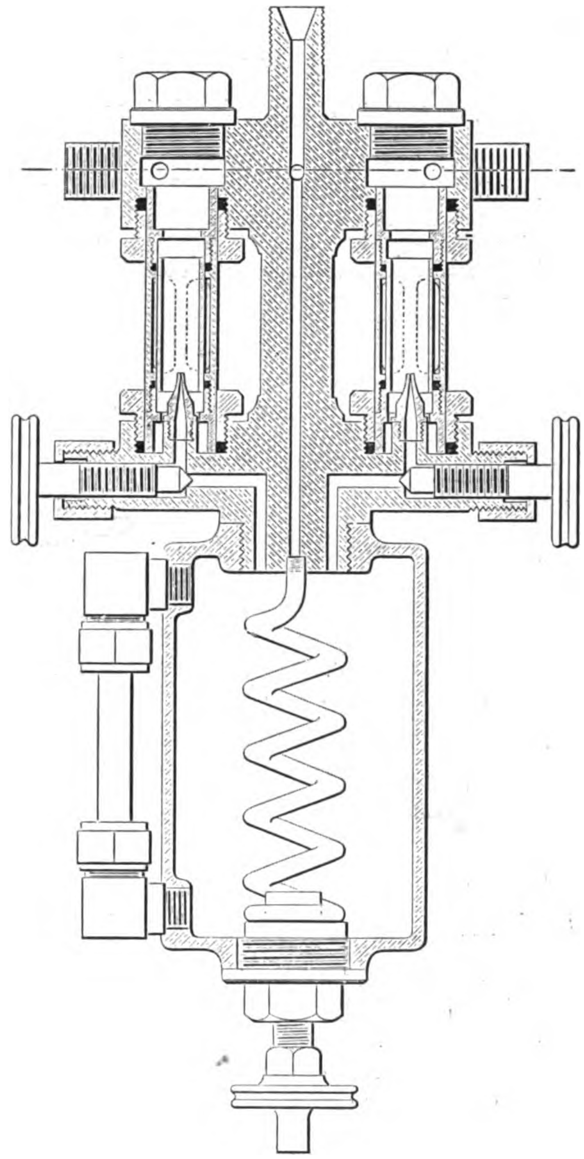


Fig. 46.

by a special arrangement of the pressure valves in the head the glasses can be maintained perfectly clear, even with the oil rising at 200 drops per minute.

The oil is delivered into the main steam pipes or steam chests as required, in such a manner that the steam is thoroughly impregnated with the lubricant, thus reducing

*Copyright. No. I. of this series appeared in February, 1907; No. II. in March, 1907; No. III. in April, 1907; No. IV. in May, 1907; No. V. in June, 1907; No. VI. in July, 1907; No. VII. in August, 1907; No. VIII. in September, 1907; No. IX. in October, 1907; No. X. in November, 1907; No. XI. in December, 1907; No. XII. in January, 1908; No. XIII. in February, 1908; No. XIV. in March, 1908.

the valve face and cylinder wall friction to a minimum. When the oil is delivered into the steam chest, as is often the case, a single lubricator is usually sufficient for inside cylinder engines, but if for outside cylinders one double or two single "sight feed" lubricators are necessary for the separate steam chests.

When first introduced for stationary purposes coils of tubing or chambers in the steam supply pipes were fitted well above the body of the lubricator, in order that a column of water could be formed in the coils, by the condensation of the steam supply. The lubricators were fixed in such a manner that the pressure of the steam inlet was equal or nearly equal to the pressure against which the oil was to be delivered, and the gravity of the water was utilised behind the oil, thus forcing it toward the parts to be lubricated.

The long condensing coils and the necessarily slender connections were unsuitable for other than stationary purposes, so that considerable improvements in the design of the lubricators were necessary before they were adaptable to the locomotive.

Modern improvements have rendered these external condensers or slender coil connections unnecessary, and as a consequence the lubricators have been much simplified, with a correspondingly greater adaptability for locomotive purposes.

In the Hulburd's Patent Sight Feed Lubricator, fig. 46, an internal condenser is so contrived that it protected from damage by frost, and an immediate condensation is continuously obtained as soon as steam is admitted

The Wakefield's Patent Double Sight Feed Locomotive Lubricator, with Auxiliary Feed, fig. 47, is a very popular type and is extensively used.

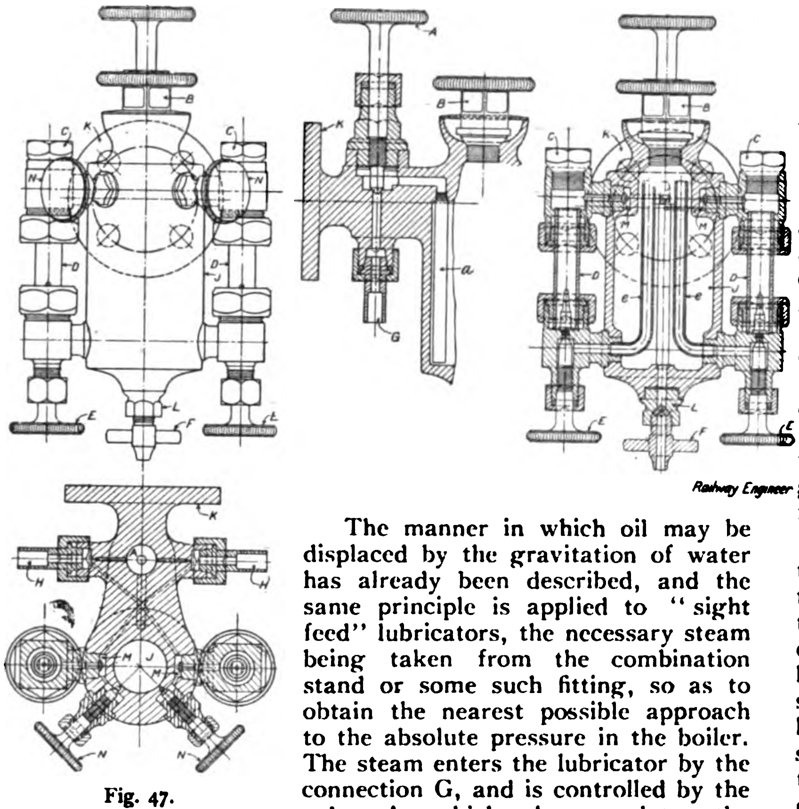


Fig. 47.

The manner in which oil may be displaced by the gravitation of water has already been described, and the same principle is applied to "sight feed" lubricators, the necessary steam being taken from the combination stand or some such fitting, so as to obtain the nearest possible approach to the absolute pressure in the boiler. The steam enters the lubricator by the connection G, and is controlled by the valve A, which also regulates the flow of the oil as it passes to the outlet pipe H, and thence through the oil pipes leading to the steam chests. The steam inlet tube *a* terminates in the lower part of the oil vessel J, so that the oil is forced upward by the condensation, and through a delivery tube *e* which stands vertical with its open end inside the upper portion of the vessel J. This delivery tube, which is connected to the passage leading into the nipple in the bottom of the "sight feed" glass D, stands full of oil, when the lubricator is working, ready to be delivered at any desired rate as regulated by the small wheel valve E, which controls the before-mentioned oil passage *e* leading to the nipple. The wafer in the sight glass being subjected to pressure at both the inlet and delivery side is practically in equilibrium, so that the oil when discharged from the nipple rises by its levity through the water past the valve M to the pipes H leading to the parts to be lubricated. A small automatic check valve M into the passage leading from the sight glass to the outlet H so that when the equilibrium is disturbed by the bursting or breaking of a glass the valve is held tight upon its seat by the pressure behind, thus protecting the driver and fireman from scalding by preventing the escape of steam. When a break occurs the valve E must be closed, and the auxiliary feed valve N, which is closed when the lubricator is working normally, should be put into operation by opening it the same proportion of turn that obtained with the valve E. Bye-pass passages, which are controlled by the valve N, lead from the upper portion of the oil vessel to the outlet H, so that when opened the auxiliary valve continues to feed the oil as before, until the broken glass has been replaced, normal working being resumed by closing N and opening the valve E.

The method of filling and starting is practically the same in all types of "sight feed" lubricators. With all valves closed, remove the plug B and fill the vessel full. It is good practice to fit a small gauze strainer or sieve into the mouth of the vessel, so that it will retain any grit or foreign substance that may be present in the oil, and which would tend to choke up the passage in the lubricator. After replacing the plug, release the valve A slowly from its seat, so as to allow condensation to gradually fill the "sight feed" glass. When the glass is filled with water regulate the oil supply with the valve E, six drops per minute being usually ample for ordinary conditions. The starting of the lubricator should not be done in a hurried manner, as the oil is liable to become agitated, and mix to a certain extent with the water, thus obscuring the sight glasses before steady working has commenced. To re-fill the vessel, close the valves A and E, loosen drain-cock F to draw off the water, and remove plug for filling as before. The seat of the drain-cock should be maintained in good order, so that sufficient pressure can be applied with the hand for closing the drain and preventing any drip. The remarks previously applied to a lubricator drain-cock are equally applicable here. Seeing that the oil is fed by the condensation of the steam, care should be taken that the oil vessel is not entirely emptied before re-filling, otherwise the lubricator may get too hot for condensation to take place efficiently, and it would have to be cooled before displacement could commence. On the other hand, in frosty weather the water should be drained from the oil vessel and the drain-cock left open before putting the engine away, to guard against the liability of bursting the oil vessel by the freezing of the water.

The thick oil which is used for cylinder lubrication is apt to cling to the passages or pipes contained in the lubricator, thereby impeding the free movement of the oil, and causing the lubricator to show signs of sluggishness when cleaning out becomes necessary. This can be done by passing petroleum through the various passages and afterwards blowing steam through, so as to remove the dirty substances which have been loosened by the petroleum. Little more need be said about lubrication, providing the driver adapts himself to the various conditions and circumstances affecting the efficiency of his methods.

Referring again to the subject of lubrication generally, it may be said that attention to detail and system are absolutely necessary. A bearing or journal, for instance, maintained in good order will give little trouble under ordinary conditions, but if the same bearing is subjected to the slightest neglect it is apt to get out of hand, and, once having become heated, the rubbing surfaces may be damaged by the seizing or scoring that may take place, and sufficient heat may also be generated to seriously damage the parts affected by the expansion of the metals, so that considerable time, trouble and

patience will have to be sacrificed before the refractory bearing assumes its normal working condition.

Dust or grit picked up whilst running may often so seriously damage the surface of a bearing or journal that considerable attention is absolutely essential to prevent permanent abrasion or scoring of the wearing surfaces. Under these circumstances special methods of lubrication should be adopted, such as the introduction of graphite or some such material, otherwise overheating or seizure is likely to occur.

The Joseph Dixon Crucible Company are well-known manufacturers of a special flake graphite, which by reason of its perfect smoothness is suitable for application to refractory bearings or journals.

At the same time it should be pointed out that however careful a driver may be if the various journals or bearings are not properly fitted together in the shops no amount of lubrication will make them run cool, so that if any doubt exists as to the proper adjustment of the different parts owing to any particular bearing persistently running warm, a driver should not hesitate to report the matter.

(To be continued.)

Notes on the Erection of Cantilever Bridges.*

This paper deals with the erection of cantilever bridges by the process of corbelling forward, and the temporary stresses which take effect when the process is extended to the central "independent" span, by using its panels as a temporary prolongation of the cantilever. During this part of the process the stresses due to the weight of the structure are greatly changed—not only in the members of the independent span, but also in the cantilever. The river-arm and also the shore-arm of the cantilever are now subjected to greater bending moments and greater boom-stresses, and these are briefly referred to; but the more important changes are those which will generally take effect in the web-system of both arms of the cantilever, and they become especially important when the web-system consists of vertical posts and diagonal ties designed to act only in tension.

Taking any ordinary form of cantilever, of varying depth, it is shown that, while the vertical shearing force at all points in the river-arm undergoes no change under the altered condition of the structure, yet the tensile stress in the diagonal of every *tapering* panel is considerably *less* than the stress due to the same load in the completed bridge. Thus, it is possible that the tensile stress in one or more diagonals may fall to zero as soon as the corbelling process reaches a certain definable stage, and if the process goes further the stress may be reversed in direction. Any such reversal of stress would tend to induce a buckling of the lower boom, and it is, therefore, necessary to examine this contingency in detail.

To define and to simplify the problem, the cantilever is first treated as a pin-connected frame of discontinuous bars, free to turn at the joints (the diagonal ties being flexible). The arm, which projects beyond any given panel, can then be examined in respect of its equilibrium while the process of corbelling goes on; and the stability of the arm vanishes as soon as its centre of gravity reaches a certain critical point *P*. If the corbelling process is carried any farther, the collapse of the pin-connected frame follows as a necessary consequence from the upward buckling of the lower boom at one or more of its joints.

The critical point *P* is determined for each panel by a simple graphic method, and serves the purpose of a metacentre, so that the question of stability can readily be determined when the centre of gravity has been found.

Passing from the hypothetical illustration, the lower boom is next considered as a continuous member following the same general outline; and the upward buckling tendency is most clearly apparent when the member is designed to follow an arched outline (convex upwards). The continuity of the member does not greatly alter the governing conditions as found in the pin-connected frame. At any stage in the corbelling process the same forces are in operation producing the same buckling tendency; and as the centre of gravity moves out to the point *P*, the lower boom passes under a new set of conditions. It first loses the support of those forces or reactions on which it had depended for its stiffening in the vertical plane. Then, as the corbelling goes on, the boom is subjected to positive transverse bending forces or stresses with an ever-increasing tendency to push forward the upward buckling movement.

The shore arm of the cantilever is to be treated in the same way, the anchorage force being duly taken into account; for in this arm also it is equally necessary to consider the possible contingency of an upward buckling of the lower boom under like conditions of equilibrium.

The general practical question whether the corbelling process can be carried out so far as to reach the centre of the span (or to reach any given intermediate point), without involving this contingency in either arm of the cantilever, must depend in each individual case upon the features of the design—the length and weight of the independent span, the geometrical form of the cantilever, and the curvature of its lower boom—and also upon the actual distribution of the load upon every panel of the bridge.

* Abstract of a paper by Prof. T. Claxton Fidler, read before the Institution of Civil Engineers.

4-6-2 "Pacific" Engine; Lake Shore and Michigan Southern Railroad.

It will be noticed from the particulars given below of these engines that their tractive effort approximates closely to that of the "Pacific" engine—illustrated in our last issue—recently designed for the Great Western R. by Mr. G. J. Churchward, and on this account it may be interesting to compare the leading dimensions and ratios of the two designs. We have therefore added them to the particulars, for which we are indebted to the *Railway Age*, given below:—

Since 1901, when the first "Prairie" type engine was put in service on the Lake Shore and Michigan Southern R. this type has been the favourite in heavy passenger service on that railway. Recently, however, this company placed an order with the American Locomotive Co. for 25 "Pacific" type engines, which are illustrated herewith. These locomotives are, with the exception of the "Pacific" recently built for the Pennsylvania R., the heaviest passenger engines ever built by the American Co. Another interesting feature is the application of a combustion chamber to the last three engines of the order.

As compared with the heaviest class of "Prairie" type engines now in service on the L.S. and M.S.R., the engines illustrated have about the same weight on driving wheels, the same diameter of drivers, and the same boiler pressure, but, with cylinders ½in. larger in diameter, they have a greater tractive power.

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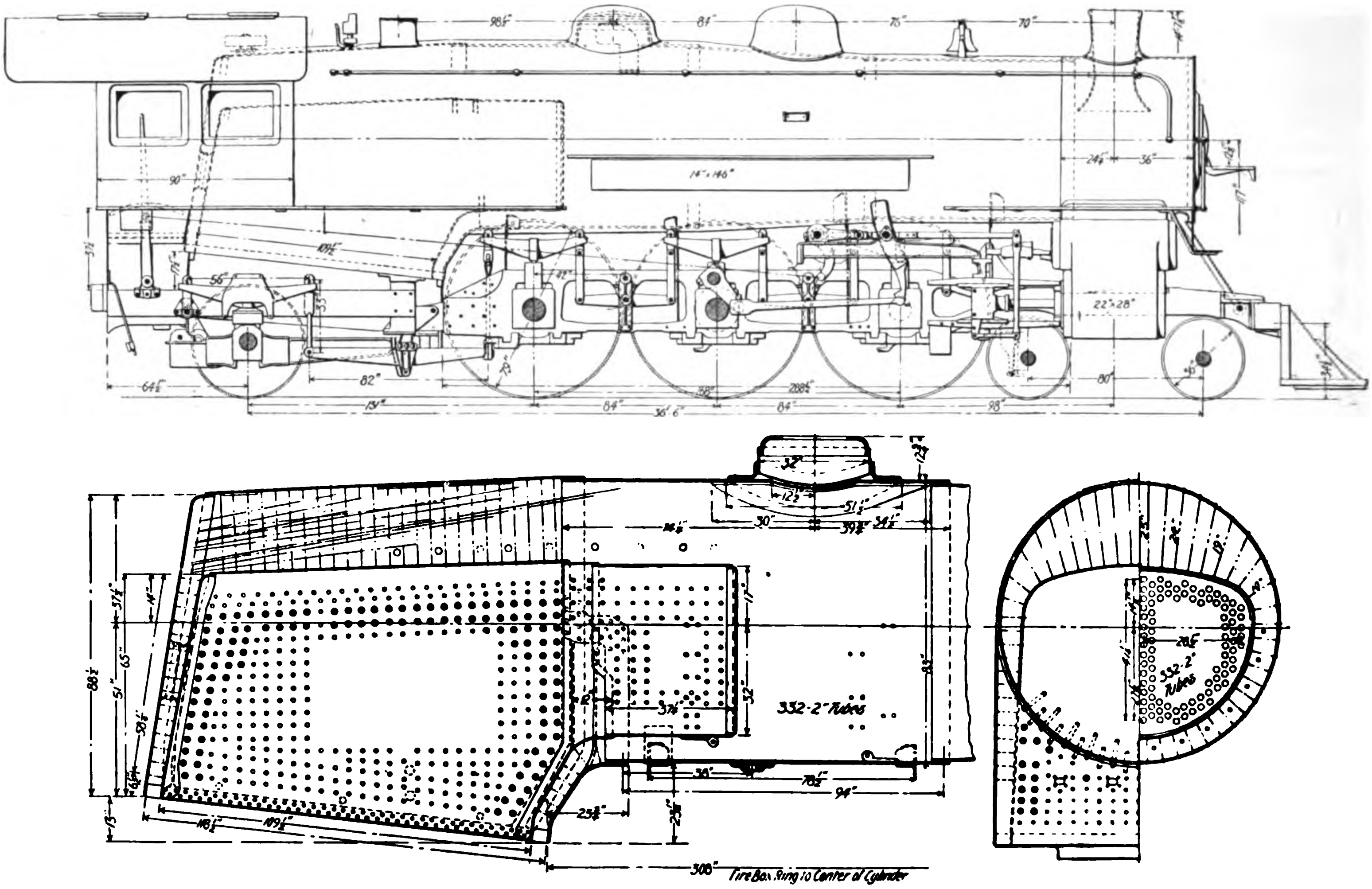


4-6-2 "Pacific" Engine; Lake Shore and Michigan Southern RR.

The following table gives the principal dimensions and ratios of the two types, together with those of the Great Western R. 4-6-2 engine:—

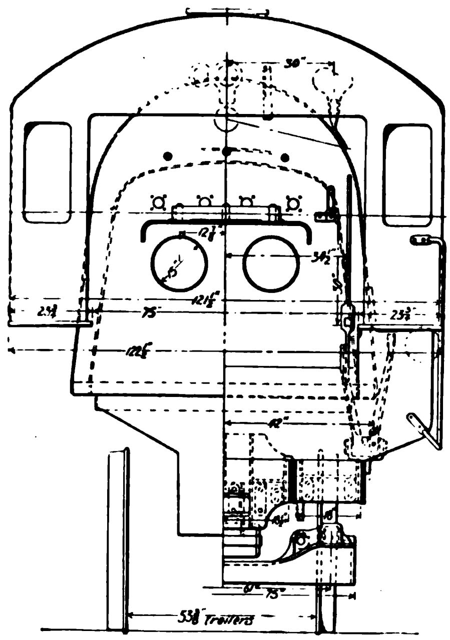
		With combustion.	Without.	Great Western Railway.
Type	2-6-2.	4-6-2.	4-6-2.	4-6-2.
Total weight, lb.	244,700	261,500	261,500	218,960
Weight on drivers, lb. ...	170,000	170,000	167,000	134,400
Tractive effort, lb.	27,850	29,200	29,200	29,430
Size of cylinders, in.	21½ × 28	22 × 28	22 × 28	15 × 26
Total area of cylinders, sq. in.	726·1	760·3	760·3	706·84
Diameter of drivers, in. ...	79	79	79	80½
Total heating surface, sq. ft....	3,905	4,195	3,409	3,400·81
Grate area, sq. ft.	55	56·3	56·3	46·79
Tractive effort ÷ total heating surface	7·13	6·96	6·56	8·66
Weight on drivers ÷ tractive effort	6·1	5·83	5·72	4·56
Total weight ÷ tractive effort	8·8	9·03	9·03	7·47
Tractive effort × diameter of drivers ÷ heating surface	563	550	675	697·00
Total heating surface ÷ grate area...	71	74·5	60·5	81·4
Total heating surface ÷ volume of both cylinders ...	332	340	276	261·0
Firebox heating surface ÷ tube heating surface, per cent....	6·17	4·92	8·62	5·0
Weight on drivers ÷ total heating surface	43·6	40·5	48·9	39·5
Total weight ÷ total heating surface	62·7	62·4	76·7	64·4
Equated heating surface ...	1,061	1,091	1,002·3	—
Tractive effort × diameter of drivers ÷ equated heating surface	2,070	2,114	2,302	—
Total weight ÷ equated heating surface	230	239	260	—

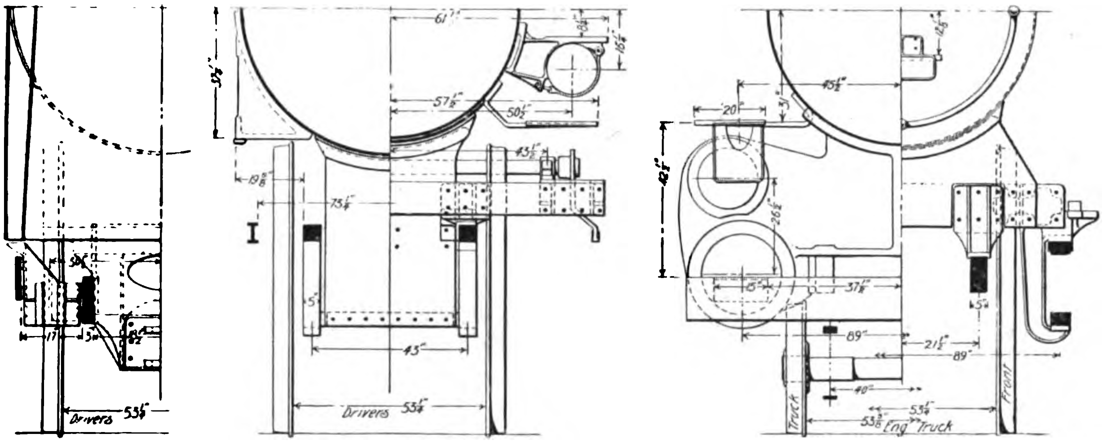
It will be noticed from this table that in the "Pacific" engine 340 sq. ft. of heating surface for every cubic foot of cylinder volume has been provided; also that the figure representing the "boiler-driver" factor or factor of steam consumption (tractive effort × diameter of drivers ÷ heating surface = 550) is well within the usual limits for this type of engine, which would indicate that these engines have a large boiler capacity for high speed sustained for long periods.

A careful comparison of the ratios of the two types will also show that especial care has been taken in the design of the "Pacific" engines to provide the same satisfactory proportion between boiler and cylinder capacity as were obtained in the "Prairie" type engine.

The boiler is of the radial stayed type, with conical connection, the outside diameter of the first or smallest course being 72in. The boilers without combustion chambers contain 379 tubes 2in. diameter and 20ft. long. In the boiler with combustion chambers shown in the accompanying illustration the only changes made are the introduction of the 4ft. combustion chamber and a reduction in the number and length of the tubes; otherwise they are the same as the boilers of the other engines ordered. The tube plate has been moved ahead so that the tubes are 18ft. long, or only 2ft. shorter than in the engines without combustion chamber, although the combustion chamber is 4ft. long. The number of tubes has been reduced to 332, as against 379 in the other engines. These changes reduce the tube heating surface 848 sq. ft., or 21·4 per cent., while the firebox heating surface is increased 62 sq. ft., or 33·4 per cent. Results from the use of the combustion chamber on the Northern Pacific R. have shown that the increase in firebox heating

surface fully offsets the decrease in tube heating surface and the evaporative efficiency of the boiler is in no way decreased by the introduction of this feature. The relative steaming qualities of the two boilers here described is best shown by a comparison of the figures in the table for equated heating surface. These figures are obtained from H. H. Vaughan's





4-6-2 "Pacific" Engine; Lake Shore and Michigan Southern Railway.

formula, which puts the efficiency of the tube heating surface as inversely proportional to the square root of the length of the tubes in feet. By such a comparison it will be seen that although the total actual heating surface has been reduced 786 sq. ft., or 18·7 per cent., the total equated heating surface has been reduced only 89 sq. ft., or 8·1 per cent., which would indicate that the engine with combustion chamber will steam fully as well as those not so equipped.

As will be seen from the illustration, the combustion chamber is stayed to the shell of the boiler by radial stays on the bottom and sides and by expansion stays on the upper section. A number of 1½in. rod stays between the chamber and the shell of the boiler serve to further stiffen it. The water space between the chamber and the shell of the boiler is about 8¼in. at the bottom and 7in. at the closest point on the sides, which gives ample space for good circulation.

The application of the combustion chamber to these engines, as to also two of another duplicate order of 20 for the same railway, and to the 6 decapod engines recently completed for the Buffalo, Rochester and Pittsburg R., shows the increasing popularity of this feature as a means of reducing boiler trouble.

Another interesting feature of the design is the arrangement of the Walschaert valve gear, which is similar to that employed on the "Pacific" locomotive built for the Pennsylvania R. by the American Locomotive Co. The link is located just behind the centre of the forward driving wheels and is supported on a steel casting outside of the driving wheels, which extends between the guide yoke and the frame cross stay between the first and second pair of driving wheels. The reversing shaft is supported on the back end of this same casting and the reverse shaft arm is directly connected to the radius bar by means of a slip joint.

The principal dimensions and weights are:—
Cylinders, 22in. by 28in.
Boiler, diameter first ring, 71 15/16in.
Boiler pressure, 200 lbs.
Firebox, 75¼in. by 108½in.
Tubes, number, 379.
  Gauge, B. W. G. No. 11.
  Diameter, 2in.
  Length, 20ft.
Heating surface: Tubes, 3,960·6 sq. ft.
  Firebox, 206 sq ft.
  Arch tubes, 28·4 sq. ft.
    Total, 4,195 sq. ft.
Valves: Type, piston.
  Maximum travel, 6in.
  Steam lap, 1 1/16in.
  Exhaust clearance, 1/16in.
  Setting lead, ¼in.
Back engine truck wheels:
  Diameter, 50¼in.
  Journals, 8in. by 14in.
Grate area, 56·3 sq. ft.
Driving wheels: Diameter, 79in.
  Journals, 10½in. by 12in.
Front engine truck wheels:
  Diameter, 36in.
  Journals, 6½in. by 12in.
  Wheel base: Driving, 14ft.
  Rigid, 14ft.
  Total engine, 36ft. 6in.
  Engine and tender, 67ft. 10¼in.
Tender: Water capacity. 8,000 gallons.
  Coal capacity, 14 tons.
  Journals, 5½in. by 10in.
Weights: On drivers, 170,700 lbs.
  Total engine, 261,500 lbs.
  Engine and tender in working order, about 423,700 lbs.
  Tractive effort, 29,200 lbs.

Locomotive Lubrication.*

With reference to high steam pressure and superheated steam.

At the 1906 convention, your committee reported that for locomotives with steam pressures as high as 225 pounds, or those using super-heated steam, the temperature of which is as high as 600° F., the ordinary valve oil has been found by experience to be quite suitable, and the problem is one of delivering the oil in proper quantities to the places needing it; your committee believes the latter is possible with the modern sight-feed lubricators now in use.

*Report of the Committee—Messrs. D. R. MacBain, R. D. Smith, R. F. Kilpatrick, C. Kyle, and W. O. Thompson—to the American Master Mechanics' Association.

How far may we economise in lubrication, both internal and external?

Internal Lubrication.—Internal lubrication should not be stinted, for it is more important that an engine perform its work properly and without undue wear or heating. Dry valves and dry cylinders mean rapid wear of the surfaces of contact in the steam chest and cylinders, also excessive trouble with the valve motion parts. Too much economy in the use of oil for internal lubrication is apt to result in hot or slipped eccentrics, broken eccentrics, eccentric straps, links, transmission bars, rockers, valve stems, and connection pins, and aside from the increased machine friction, the performance of the engine is affected. Hard-running valves cause a derangement in steam distribution, and worn packing in valve chambers or at rods causes a loss due to leakage.

With the slide-valve locomotive there is not so much danger of these troubles, as the jar of the reverse lever attracts attention to the fact that oil is needed and the engineman will see that the valves are properly lubricated. With piston-valve locomotives the internal lubrication may be much below the reqpired amount without any indication from the reverse lever, and the cause of the trouble may operate a long time before being discovered; in other words, the engineer on a slide-valve engine, even on a small allowance of oil, is more apt to keep the valves supplied with enough oil to prevent hard service to the machine, while with piston-valve engines he does not have this indication that the valves need oil, and no one knows that the parts have been running too dry until trouble comes through heated bearings and worn or broken parts.

Your committee feels that for internal lubrication, 70 miles per pint for large freight locomotives and 80 miles per pint for large passenger locomotives seems to be the amount needed to lubricate properly. The amount for each class depends upon the speed at which the locomotive is running; in bad water districts the oil allowance should be increased about 25 per cent.

External Lubrication.—The use of grease on crank pins and driving axles seems to offer the best solution of how to decrease the cost of external lubrication and at the same time secure the best results. The committee report of last year gave some experiences with 203 locomotives, showing that grease as a lubricant, gave results about as follows:—

(a) Reduces engine failures due to heated journals and pins.

(b) Reduces cost of lubrication.

(c) Reduces cost of labour incident to inspection, cleaning and renewal of lubrication packing.

(d) Reduces delays incident to oiling.

(e) Reduces cut journals incident to oil lubrication.

(f) Possibly produces a slight increase in machine friction.

In reference to the cost of external lubrication as compared with that of, say, four years ago, your committee believes that the cost per square inch lubricated, or per pound carried, is less with the use of hard grease than when oil was in general use.

The consideration of sight-feed lubricators versus pumps for internal lubrication.—Your committee is of the opinion that a well-designed sight-feed lubricator, having pipe connections suitably arranged to deliver the oil in the most direct way to the parts needing it, will under present conditions do the work properly. On superheated locomotives it is, we believe, generally conceded that there should be one pipe from the lubricator leading direct to the cylinders and attached to separate plugs near the centre, so that the oil fed from the lubricator for the cylinder may be properly distributed. The question of location of plugs in the steam chest is one point on which we find considerable difference of opinion; one member of your committee, who has had considerable experience with superheated steam, favours putting the steam chest plugs at the end of the valve chest in preference to attaching the oil pipe to the centre of the chest and letting the oil be carried by the steam to the parts where needed; and your committee as a whole believes that the question of locating steam chest connections is one that can be left open, and, therefore, do not care to make any recommendations.

Crewe; London and North Western Railway.

(Concluded from page 102)

III. Tranship Shed.

Not the least interesting feature of the yards at Crewe is the Tranship Shed and the work done therein. It is a well-known fact that the bulk of the goods traffic on British railways consists of small consignments, and consequently the bulk of the wagons carry only small loads. The purpose of the Tranship Shed at Crewe is to act as a centre for the L. and North Western R., where small loads may be sent, which are there unshipped, and whence full wagons with complete loads of small consignments from all over the system are despatched to every point.

A plan of the Tranship Shed is given in fig. 8, and in fig. 9 is a view of the interior, looking north. There are four decks similar to those seen in the illustration, which shows No. 2 deck, and there are seven roads through the shed. The offices are on the west side the bottom of fig. 8 and each road holds 16 wagons except No. 7—the most easterly- which holds 18 wagons. Communication is given between the decks by two pairs of gangways, which are balanced and rise and fall freely. At each end of the shed there are signals that are coupled to the gangways, and which go to danger when the gangways are across the lines. Each deck is apportioned out to different purposes, and space is allotted out to traffic for certain points. These are known by numbers and names. For instance, as seen in fig. 9, Derby, Mid. is 88, Aberystwith, Cam. is 89 and Machynlleth is 90. Consignments, then, for these places are placed in the space under the numbers, and at the proper time a wagon is put into position to receive the goods for these places.

There are over 200 of these berths and practically every town of importance in the United Kingdom is provided for, and an alphabetical index is kept of these showing how consignments are sent—whether direct or to some junction point. For instance, goods for Tipton are placed on berth No. 60 for Tipton, those for Torquay are sent to Exeter—berth No. 99—whilst Thrapstone in Northamptonshire is served by the Peterboro' road van from berth No. 181. This latter item leads to the remark that every station on the L. and N.W. R. is served from Crewe, the smaller ones being supplied by road vans. There are from 250 to 300 stations served direct each day. and 519 stations are served by road vans. The road vans are worked to a regular programme daily, both to and from Crewe. That for Peterboro' takes the traffic for Billing, Castle Ashby. Wellingboro', Ditchford, Higham Ferrers, Ringstead, Thrapstone, Thorpe Barnwell, Oundle, Elton, Wansford and Overton. It leaves the Tranship Shed for Basford Hall sidings at 7 p.m. and the Sorting Sidings for Rugby at 9.50 p.m., Rugby for Northampton at 2.10 a.m., and Northampton for Peterboro' at 7.30 a.m., leaving goods at each of the stations just named. Another example is Blackburn, which leaves the Tranship Shed at 12 midnight for Basford Hall, and thence at 4.50 a.m. for Wigan, and Wigan for Blackburn at 7.35 a.m.,

supplying all the stations on the Lancashire Union line between Wigan and Blackburn. There are 48 such road vans, and a time-table is drawn up as to the hour at which the wagons and road vans are to be drawn from the Shed, the times they are to leave for Basford Hall Sidings, and the trains to which they are to be attached.

The transfer of consignments is, of course, regulated by, and checked with, the invoices. These come by passenger train to Crewe Station or on the wagons, whence they are taken to the office and there impressed with a rubber stamp. They pass then to the markers, who mark thereon the No. of the berth and the No. of the road. For instance, Builth Road would be marked $\frac{28}{1}$, signifying No. 28 berth on No. 1 road. The markers are very quick at this. They have the assistance of the alphabetical index already referred to, but the writer noticed that they never referred to it, but put all the numbers on from memory. When this has been done the invoices for each wagon are put together and placed in a pigeon-hole until the wagon has to be unloaded. It will be readily appreciated how much more easy it is for a man to find a number than a name, and consequently how much quicker the work is done. The unloading and loading of each wagon is superintended by a checker, and each checker on coming on duty is handed two forms, for which he has to sign. These are headed as follows, the "Loading List" being on white paper and the "Unloading List" on yellow paper :—

On the loading list the checker enters particulars of the wagons he loads and of those he unloads on the unloading list. The letter "P" in the last column on the loading list is for a description of the wagon used. They are divided into piped vans, vans, 4 plank, 2 plank, and 1 plank, and this information assists in seeing that the best use is made

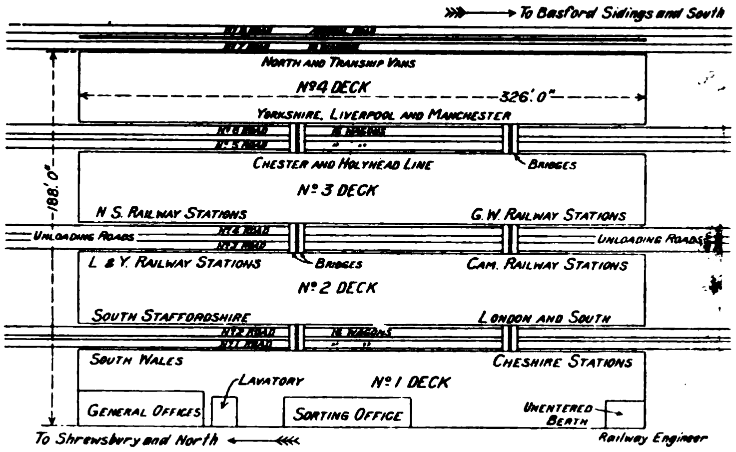


Fig. 8.

of the different classes of stock. On the back of each sheet the checker gives the names of the men that assist him, their check numbers, and a total of the weight they have dealt with and the bonus due to them.

When a wagon has to be unloaded the checker goes to

L. & N. W. R.-LOADING LIST.

*Checker*________ *Loader*________ *Date*________

WAGON.		FOREIGN SHEETS.		STATION TO	Total Weight in L. and N.W. Wagons.		Total Weight in Foreign Wagons and Road Vans.		Time finished Loading.	"P" for planks "T" for tons.
Owner.	Number.	Owner.	Number.		T.	C.	T.	C.		
										P......... T.........
										P......... T.........

L. & N. W. R.—UNLOADING LIST.

*Checker*________ *Date*________

WAGON.		FOREIGN SHEETS.		STATION FROM	Weight in Foreign Wagons less than 1 ton.		Date of Label.	Time finished Unloading.
Owner.	Number.	Owner.	Number.		C.	Q.		

Fig. 9.

the office for the invoices, and having signed for them he goes with his gang to the wagon. In each unloading gang there are seven men—the checker, a "turner-out," a "caller-off," and 4 truckmen. The "turner-out" stands in the wagon and puts the goods on the stage. The "caller-out" reads the address to the checker, who checks the invoice and calls out from the invoice the berth and road number put on by the "marker," which the "caller-on" endorses on the label, and then one of the truckmen wheels the consignment to the designated berth.

The checker then puts the weight of the goods unloaded on his list and takes the invoices back to the office, where the weight is checked, and then the invoices are sorted on to numbered spikes—a spike for each berth, the invoice of the consignment for Builth Road being put on No. 28 spike. Thus as the load of the wagon accumulates so its invoices accumulate on the corresponding spike in the office.

Loading and unloading go on continuously and simultaneously. Only three men are in a gang for loading a checker, a "caller-off," and a "loader." The "caller-off" sorts the consignments out, putting the heaviest at the bottom, calls out the addresses, which the checker checks, and the loader places them in the wagon. The checker then marks the wagon number on the invoices, and the latter—which the checker has had to sign for—are returned to the office, where the weight claimed by the checker is tested and the invoices are then dealt with in the usual way.

One of the features that have made the Tranship Shed so successful is the payment of a bonus to the men. This is as follows:

Loading Gangs.—5d. per ton on all weights loaded in excess of 23 tons per gang per 10 hours day. To be apportioned as under, viz.:—

Checker	2d. per ton.
Caller off	1½d. per ton.
Loader	1½d. per ton.

Unloading Gangs.—9d. per ton on all weights unloaded in excess of 42 tons per gang per 10 hours day. To be apportioned as under, viz.:—

Checker	2d. per ton.
Callers off	1½d. per ton.
Unloader	1½d. per ton.
4 Truckers	1d. each per ton

Conditions.

1. Each checker will be responsible for keeping a correct record of the weight he and his gang deal with each day on his unloading and loading lists. He must also show on the back thereof the names and check numbers of the men forming his gang or gangs, and the hours made by each man.

Weight checkers will be appointed to test the accuracy of the weights, and other particulars entered by the checkers on their work slips, and any discrepancies detected will be reported and registered against the persons to blame.

2. No credit must be taken by either unloading or loading checker for the weight of any goods left on wagons by the former to be "made up."

3. In the event of any man attached to an unloading gang failing to turn up to duty at the proper time, it will be in the discretion of the foreman to either put on another man in his place, or work the gang shorthanded; but in the latter case the minimum weight of 42 tons per gang will be proportionately reduced, for instance, a six-handed gang will only be required to unload 36 tons before becoming eligible for bonus.

Fig. 10.

In every case where a gang is shorthanded, the checker must, as soon as possible, enter the names of the men actually working on his slip and get the weight checker or foreman to certify it as correct, otherwise he will not be allowed any reduction in the minimum day's weght for a full-handed gang.

4. Where the regular unloading gangs are split up for a time, and put to loading, as, for instance, between 6 p.m. and supper time, they will be paid for the time occupied in loadng at the rate of 5d. per gang per ton on the weght dealt with over the proportionate part of 23 tons for 10 hours, and similarly at 9d. per ton per seven-handed gang, for the time spent in unloading, for example.

A gang loading for four hours, and then turning to unloading for the remaining six hours, would receive bonus on any weight loaded in excess of 9 tons 2 cwts., and on any weights unloaded in excess of 25 tons 2 cwts.

5. For ordinary time purposes the rule will be as at present, viz., 60 hours to form a week's work; but the bonus additions will be calculated at the end of each day and posted on the notice board the next morning for the information of the staff. The whole of the amounts thus earned will be added to the wages of the men concerned, at the end of the week.

6. When working overtime, bonus will be paid as under, in addition to the ordinary time, and overtime wages, viz. :—

Unloading Gangs.—9d. per ton per 7-handed gang, on all weights unloaded in excess of 4 tons 4 cwts. per hour.

Loading Gangs.—5d. per ton per 3-handed gang on all weights loaded in excess of 2 tons 6 cwts per hour.

The effect this has on the men very much struck the writer, as it was all hurry and bustle, with all hands working and no drones, and yet all is done "decently and in order."

The day-shift—6 a.m. to 5.45 p.m.—consists of 12 unloading and 25 loading gangs, and the night-shift—6 p.m. to 5.45 a.m.– of 9 unloading and 18 loading gangs, and the number of men employed varies from 350 to 450, according to the traffic. The supervision of the work is done by the following staff :—

2 Yard foremen (one day, one night) for outside operations.

4 "Striking" foremen (two day, two night), unloading.

1 Loading foreman (9 a.m. to 9 p.m.), loading.

2 Shed foremen (one day, one night), regulating traffic and staff.

1 Stage inspector, detecting irregularities.

1 Loading inspector (9 a.m. to 9 p.m.), watching and economising loading.

2 Sorting office foremen (one day, one night), invoices.

2 Chief Inspectors (one day, one night), general charge, whilst Mr. Fred. W. West is the agent and in charge.

Every inspector and foreman keeps a journal, in which he records his day's work and notes any irregularities and difficulties. These after being commented on by the chief inspector are seen first thing each morning by the agent.

Another noteworthy feature is the record made every hour, day and night, in the agent's and invoice offices of the number of wagons on hand in the Shed and at the Sorting Sidings.

The principal economics effected by concentrating the tranship goods at Crewe are as under, viz. :—

(*a*) Acceleration of the cross-country goods by more direct loading.

(*b*) Saving in wagon user by raising the average loading weight per wagon, and concentrating the traffic from and for so many different stations at one place.

(*c*) Reduction of mileage charges upon other companies' stock by turning it back home at Crewe instead of allowing it to travel forward to more distant points, as it used to do in many cases before the concentration scheme was introduced.

(*d*) Relief of large stations, which formerly had to deal with many of the tranships with their important town goods.

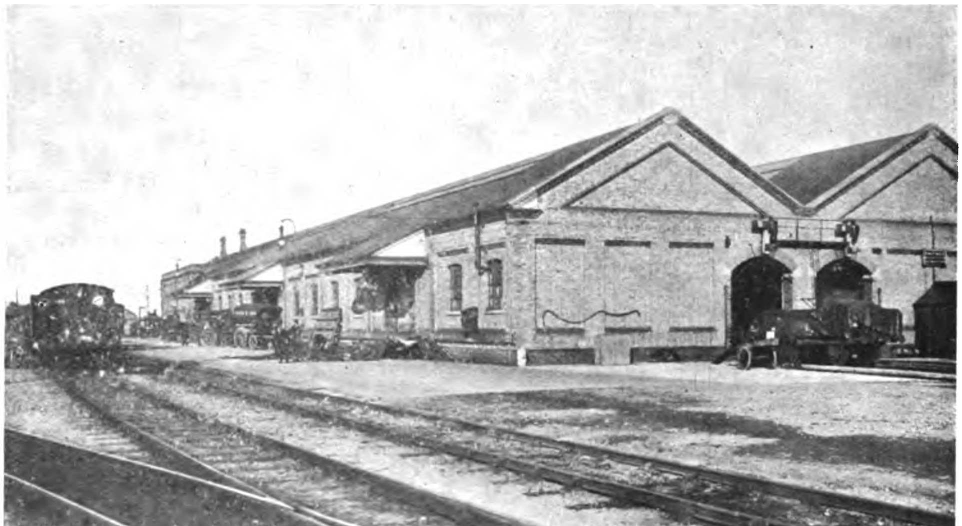


Fig. 11.

What the results are may be appreciated by the following statistics:—

Traffic dealt with, and some economies effected, since the opening of the Shed in July, 1901, for six months ending June, 1907.

Traffic.

½-year June		Transfers.	Other Traffic.	Total.	Average per month
1901	...	73,139	16,949	90,088	15,015
1902	...	109,243	18,906	128,149	21,358
1903	...	127,777	18,928	146,705	24,451
1904	...	125,476	19,615	145,091	24,182
1905	...	132,380	19,980	152,360	25,393
		Handled.	Partially handled.		
1906	...	128,699	31,556	160,255	26,709
1907	...	130,425	29,752	160,177	26,696

NOTES.

(1.) The 1901 figures represent the months August to December. The Shed opened on July 1st, 1901.

(2.) During 1903 many weights of over one ton were sent for transfer, thus unduly inflating the figures.

(3.) The weights for 1906 and 1907 are divided under the heads of "Handled" and "Partially Handled" in order to more correctly show the relations between the traffic fully dealt with by the staff, and the expenses.

Number of Wagons Used, and Average Weight of Loads.

	Received Loaded.			Loaded Outwards.		
½-year June.	Number of wagons.	Tons.	Average load T. C.	Number of wgs.	Tons.	Average load. T. C.
1901	55,896	77,150	1 7	48,623	73,981	1 10
1902	74,283	114,858	1 11	73,686	111,944	1 10
1903	71,730	133,961	1 17	70,043	131,951	1 18
1904	66,695	131,993	1 19	61,702	127,698	2 1
1905	67,857	138,781	2 1	57,404	129,940	2 5
1906	68,928	144,049	2 2	54,840	132,516	2 8
1907	69,914	142,387	2 1	54,410	136,315	2 10

If the general average of 1901, viz., 1 ton 10 cwt., had been maintained it would have required 36,466 more wagons to convey traffic from Crewe during the half-year ending June, 1907.

Foreign Wagons.

	Received.	Loaded.	Sent out empty.
1903	20,697	19,091	1,606
1904	19,121	17,302	1,819
1905	20,488	16,912	3,576*
1906	19,201	12,663	6,538*
1907	19,169	12,583	6,586*

* More local wagons loaded to foreign stations in 1905, 1906, 1907 to earn mileage.

L. and N.W. Wagons Earning Mileage.

Six months ending June, 1907 ... 5,069 wagons.

No. of Packages and Consignments dealt with Half-Year ending June, 1907.

	Number.	Daily average
Packages (averaged upon a weekly test)	3,620,916	23,211
Consignments (averaged upon a weekly test)	1,082,952	6,942
Consignments on hand at close of work each day	70,575	452
Consignments delayed one day at Crewe	1,531	9
Packages unaddressed and unidentified at close of work each day	760	4

Wagons Left Underload, Exclusive of Bank Holidays.

	Wagons.	Average per day.
Six months ending June, 1907 ...	570 ...	3

The wagons for transhipment are received from the Marshalling Sidings and placed in No. 9 siding, which is on the east side of the shed. This siding is that on the extreme right of fig. 10, and on which wagons are seen going to the shed. In all cases the shed is fed from the north end, and wagons are placed in position by electric capstans. The cranes in the shed are electrically operated.

The Tranship Shed also serves as the Goods Station or Depôt for Crewe Town, and in fig. 11 the delivery vans are seen being loaded and unloaded.

IV. Underground Goods Lines.

One important point to be achieved in any scheme for relieving the traffic conditions that used to exist at Crewe was to separate the lines for goods trains from those for passenger trains. Not only had the trains from South to North and *vice versâ* to get through the station, but all trains for Manchester and Yorkshire had to cross the lines from Chester and Liverpool and those for Liverpool and the North had to cross the Chester lines.

By the construction of the underground lines not only have the goods trains been taken out of the station, but the traffic is separated and there is no crossing.

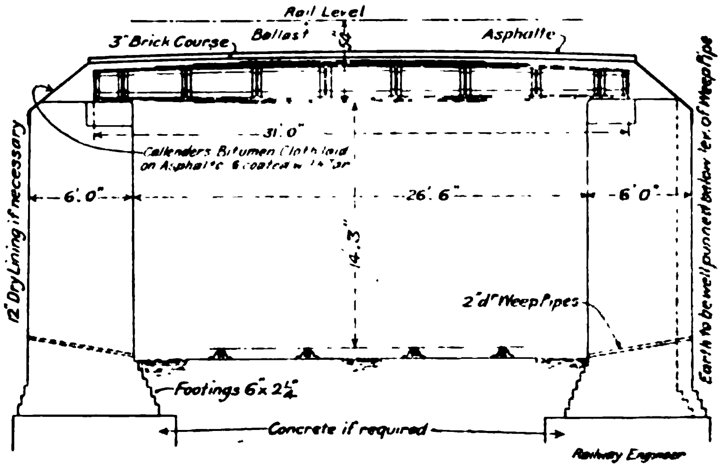


Fig. 12.

As has already been said, there are four lines of way between Sorting Sidings North and Salop Goods Junction. There are two up lines on the east side and two down lines on the west. At Salop Goods Junction two lines come in from Gresty Lane, and all six lines, by suitable junctions, form two goods lines for Chester, two for Liverpool and two for Manchester. The Chester lines are on the east side, and they join the main Chester lines near the North Junction box. The Manchester lines come next, and these fall towards the main line and pass under the Chester and Liverpool lines by a double line tunnel, 415 yards in length, which emerges on the east side, and the two goods lines run parallel with the Manchester main lines up to Sidney Bridge Junction, whence there are four lines of way—two fast and two slow. The Liverpool lines are similarly depressed, and enter two single line tunnels, one 322 and one 291 yards long, and the down line emerges on the North side of the Chester lines and joins the down fast Liverpool line at the Coal Yard box. The up goods line tunnel passes under the Liverpool lines also, and emerges to the east of them and joins the up slow

Fig. 13.

line at Coal Yard box. From Coal Yard box the four lines—two fast and two slow—continue for a distance of about 2¼ miles to Coppenhall junction, where the four lines again converge into two.

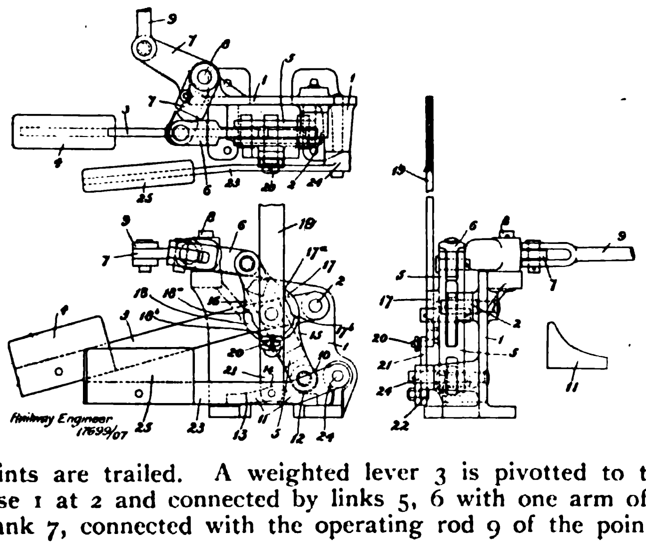
Fig. 12 illustrates a cross section of the two-way tunnel and fig. 13 shows the entrances at the south end. The greater part of the work was "cut and cover."

Recent Patents relating to Railways.

THESE abridgements of recently published specifications are specially compiled for this Review by Messrs. Wheatley and Mackenzie, Chartered Patent Agents, 40, Chancery Lane, W.C., from whom copies of the specifications can be obtained at an uniform price of 8*d.* each.

Point and Switch Mechanism. *17,699. 2nd August, 1907. A. G. Kershaw and Saxby and Farmer, Limited, 53, Victoria Street, Westminster.*

This invention relates to shunting levers which are so constructed that, whether the points be operated by hand or trailed through by a vehicle, it is impossible for them to remain in a centre or mid position. According to the present improvement the operating hand lever is arranged to automatically return to a normal vertical position when the operator releases his hold of it, and is not moved when the

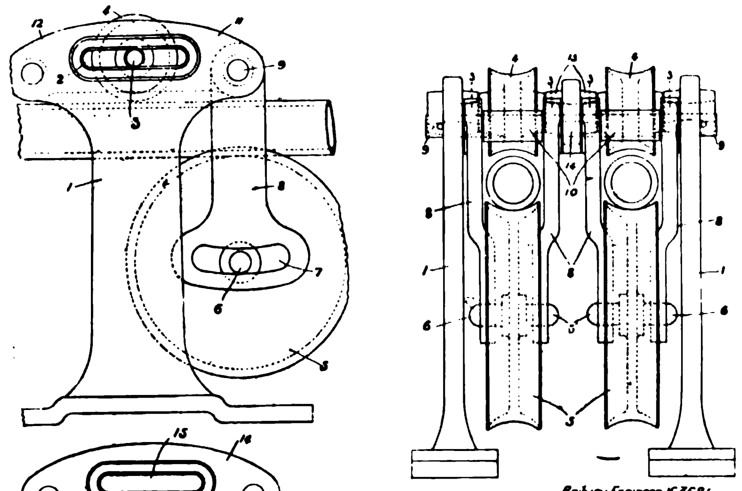


points are trailed. A weighted lever 3 is pivotted to the base 1 at 2 and connected by links 5, 6 with one arm of a crank 7, connected with the operating rod 9 of the points. The lower end of the link or lever 5 carries a friction roller 10 adapted to roll on a path 11 on the base 1, having its highest point 14 in the middle. The lever 5 has formed on it two side extensions 15, 16 provided respectively with lugs or outstanding projections 17, 18 having faces 17^a, 17^b, 18^a, 18^b adapted to be engaged by a hand lever 19 pivotally mounted on the same centre or pivot as the lever 5. The lower end or tail of the lever 19 has connected to it a suitable weight for the purpose of automatically returning it when released by the operator to a central position and for holding it there when the points are trailed through. As shown in the drawings, the tail of the lever 19 is formed with a foot or offset portion 20 pivotally connected to the upper end of a link 21. The lower end of the said link 21 is pivotted at 22 on a lever 23 itself pivotally mounted at one end, 24, on the base casting 1. The other end of the lever 23 is provided with a weight 25. On the lever 19 being pulled in a direction towards the right in fig. 1 it acts on the faces 17^a and 18^b and turns the lever 5 about its pivot, giving a pull on the crank 7 and rod 9 and moving the points. At the same time the roller 10 travels up the part 12 of the roller path 11, raising the weighted lever 3 and the parts mounted on it and passing over the raised centre or point 14 travels down the sloping surface 13, the weight 4 on the lever 3 acting to ensure the completion of the travel of the roller down the path and also completing the movement of the points. The movement of the lever 19 also gives a pull on the link 21 which raises the weighted lever 23. As soon as the roller 10 begins to travel down the part 13 of the roller path and to permit the weighted lever 4 and connected parts to fall the operator releases his hold on lever 19 and the action of the weighted lever 23 through the link 21 on the foot 20 of lever 19 immediately returns the lever to a vertical position. In this position of the parts the faces 17^b and 18^a will be in engagement with the lever 19, and on the lever being pulled in a direction towards the left in fig. 1 a similar cycle of operations takes place. When the points are trailed through motion is given to the rod 9, crank 7, link 6 and lever 5, causing the roller 10 to travel up the path 11 and over the centre and thus ensure the complete movement of the points in the same manner as if the lever 19 were operated by hand. *(Accepted 5th December, 1907.)*

Anti-Friction Supports for Point Rods. *16,368. 16th July, 1907. A. G. Kershaw and Saxby and Farmer, Limited, 53, Victoria Street, Westminster.*

This support is intended for guiding point or similar rodding, and comprises a top travelling roller 4 running in slots

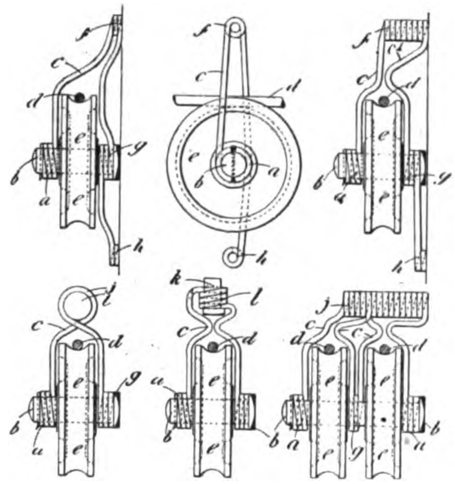
2 in the side standards and a bottom swinging and travelling roller 5. The bottom travelling roller 5 is provided with a pin or axle 6 which works in curved paths or slots formed in the hangers or stirrups 8. These stirrups 8 are supported



Railway Engineer 16368/07

by the rod 9, and are kept apart, or in position, by the tubular spacing pieces or ferrules 10. Intermediate shelves 14, supported on the rods 9 and rods 13, are provided with slots 15 for the bearing pins of the top travelling rollers. *(Accepted 5th December, 1907.)*

Pulleys for Signal Wires. *1,481. 21st January, 1907. L. W. Williams, O. R. Williams, and D. D. Williams, Railway Appliances Works, Cathcart, Renfrew.* This invention consists in forming the housings or frames of the pulleys of steel or other wire so bent into shape as to

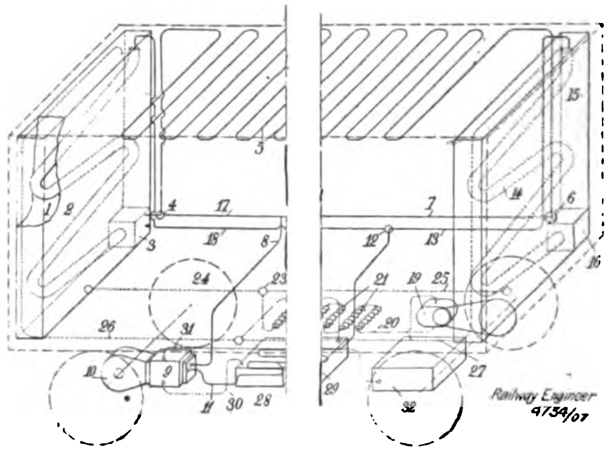


Railway Engineer 1481/07

carry the pin or bolt on which the pulley revolves. The wire is also suitably coiled to form an eye for the fixing nail or fastening. *(Accepted 12th December, 1907.)*

Refrigerating Apparatus for Vehicles. *4,734. 26th February, 1907. Date claimed under Patents Act, 1901, 6th March, 1906. The International Railway Company, Ltd., 110, Cannon Street, London.*

This invention relates to refrigerating apparatus in which liquefied gas in a receiver is vaporized and reliquefied with the aid of a pump in a second receiver, the functions of the two receivers being periodically reversed. According to this invention the fluid which aids in reliquefying the gas and which is circulated by means of a pump driven by the vehicle, is circulated around that container only which is reliquefying the gas. A bent pipe or worm 1 which is immersed in a tank of water 2 is for example that which is filled with liquefied gas. This gas passing through the expansion valve 3 and cock 4 vaporizes in the refrigerating coil 5 and lowers the temperature of the interior of the vehicle. One or several self-regulating thermometers may be employed in connection with the expansion valve to maintain the temperature of the vehicle between definite limits. On its exit from the coil 5 the gas passes through the cock 6 placed in a position such that the gas can pass by the pipes 7, 8 and be sucked in by the compressor 9 driven by the axle 10 of the vehicle and which recompresses this gas, through the pipe 11, cock 12 and pipe 13 in the worm 14 placed in the water tank 15. The gas is liquefied as fast as it comes into the worm 14. When the worm 1 is empty the worm 14 is full. The functions of the worms 1 and 14 are then reversed by the operation of the cocks 4, 6 and 12. The gas liquefied in 14 expands through the expansion valve 16, cock 6, refrigerating coil 5, cock 4 and pipes 17, 8 and is recompressed by the compresser 9 through the pipe 11, cock 12 and pipe 18 in the worm 1, where it liquefies. The water in the tank in which the gas is



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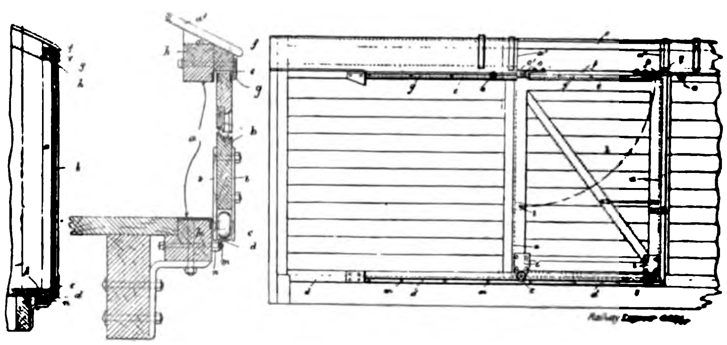
liquefied is put into circulation by the pump 19 through the pipe 20 and radiator 21, where it is cooled. From there it is circulated through the cock 23 and one of the pipes 24 or 25 into the tank where the gas is being liquefied, then by one of the pipes 26 or 27 through the tank 28 round the coil 29, where the gas commences to cool, then by 30 round the compresser 9 and from there by 31 to a water tank 32 and returns to the circulating pump 19. The turning of the cock 12 takes place simultaneously with that of the other cocks so as to put the cooling water into circulation in the tank 2 or 15 which contains the worm in which the gas is liquefying. *(Accepted 14th November, 1907.)*

Sliding Doors for Wagons or Vans. *4,150. 19th February, 1907. J. P. Crouch, Ely House, Newton Heath, Manchester.*

According to this invention the doorways on each side of a covered wagon or van are adapted to be closed by sliding doors and the cant rails, which normally extend along the roof and across the side openings and are necessary to sup-

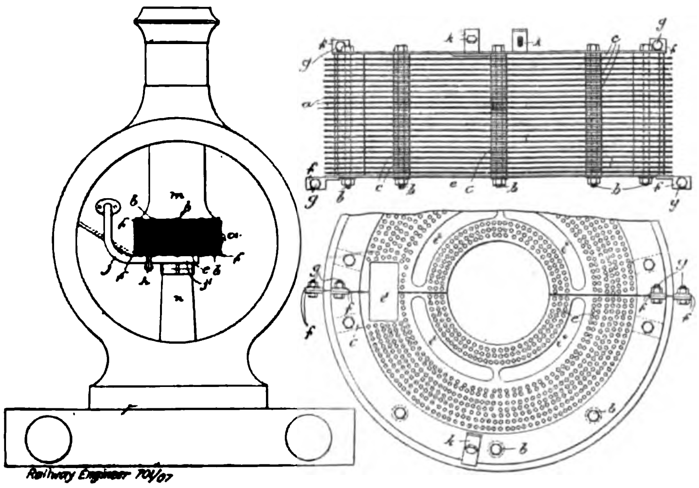


port the guides or upper parts of sliding doors, are each adapted to be moved out of the way so that the roof openings and the doorways themselves can be uncovered or opened and freed from obstruction even when the wagon is close

alongside pillars, or goods lying on stages or in warehouses. The sliding door *b* is furnished at the bottom with rollers *c* running on a fixed rail *d*, the top of the door being guided in a groove *e*. At each side of the wagon is a doorway *a* adapted to be closed by a sliding door *b* which at the bottom is furnished with rollers *c* running on a fixed rail *d*; the top of the door extends into a guide groove *e* which is formed by a bar *f* and cover plate *g* fixed to the cant rail *h* of the wagon. The rail *d*, which is of angle section, is secured to the corresponding outer longitudinal member or side rail *k* of the wagon floor by bolts *m*, distance pieces *n* being interposed between the rail and the floor member *k* so that the inner of the door bearing plates *i* of the rollers *c* extend between the angle bar *d* and the side rail *k* and thereby limit outward movement of the door *b*. That part of the cant rail *h* and its attached door guide *f*—*g* over each doorway *a* is hinged at *o* to a fixed bracket o^1, and is arranged to be held in its horizontal or operative position by a pin *p* that is passed through a hole in the free end of the pivoted portion of the cant rail and through corresponding holes in fixed lugs *q* between which such free end is then located. At each doorway *a* the roof of the wagon is formed with an opening a^1 of corresponding width and extending from the cant rail *h* to the ridge beam r so that when the hinged portions of the cant rails are lowered a clear opening the width of the doorways is provided right across the wagon with the exception of the ridge beam *r* at the middle. Each hinged portion of the cant rail may be held in its lowered or inoperative position by the pin *p* passed through the hole in its free end and through corresponding holes in lugs *t* which are fixed to a side member of the doorway and between which such end portion is then placed. A tarpaulin roof cover is secured at the middle of the wagon and arranged to fold down over the openings a^1. *(Accepted 7th November, 1907.)*

Spark Arresters. *701. 10th January, 1907. E. F. S. Notter, 506, Caledonian Road, London, N.*

This spark arrester is made in two halves, each built up with flat blades or plates *a* made in semi-circular or semi-annular form, which are arranged horizontally, one above the other, into a structure resembling a half cylinder, the blades being secured together at the desired distance apart by bolts *b* passing through holes in the several blades *a* and through washer-like distance pieces *c* located between them. The bolts *b* may

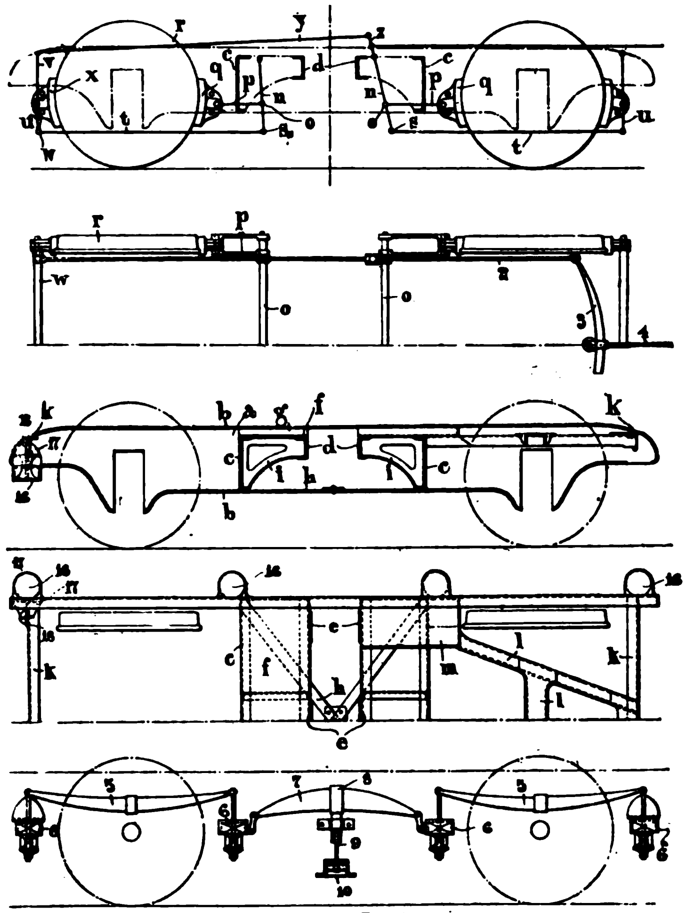


Railway Engineer 701/07

also extend through the perforated bottom plate or disc *e*, and this plate and the uppermost plate *a* are formed with lugs or ears *f* whereby the two parts of the structure can be readily secured together by bolts *g*. The perforated bottom plate *e* is cut away at e^1 to clear the flanges *h* of the pipe *j*, and also at e^2 to clear the perforations of the ring or rose j^1. Clamps *k*, *k* are fixed to the top blade, whereby the structure may be attached to the lower part of the chimney *m*. *(Accepted 28th November, 1907.)*

Bogies. *18,592. 16th August, 1907. G. H. Sheffield, 15, New Bridge Street, Newcastle-on-Tyne, and J. D. Twinberrow, 1, Woodside, Hexham.*

This invention consists in an arrangement of the parts of a four-wheeled bogie whereby the length of the wheel base may be increased without involving a proportionate increase of the bending moments on the frames, the form and disposition of the bracing between the frames may be improved, and an improved form of brake rigging may be accommodated. The side frames *a* are made of greater depth than is usual, with upper and lower edges, parallel for the greater part of the length, stiffened by flanges *b* pressed from the plate or riveted to place, cutting of the material to waste—for the



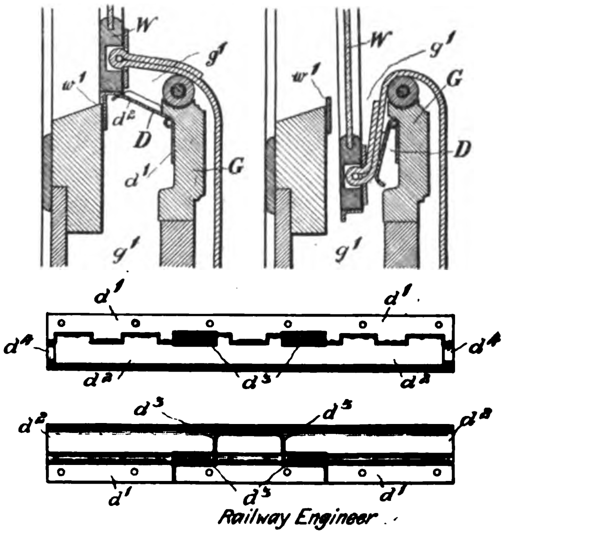
Railway Engineer 18592/07

purpose of giving an irregular outline or forming holes for reducing weight—being thereby avoided. The bogie frames *a* are transversely connected, near the centre, by means of four cross bearers *c*, *c*—*d*, *d*, instead of two, as formerly employed. The inner pair *d*, *d* are of less depth, and are fitted with facing pieces *e*, and guides for the bolster. Owing to the support afforded by the improved bracing, facing pieces can be fitted to the bearers at the middle of their length to take the fore and aft thrust directly to or from the central pivot. The outer cross bearers *c*, *c* are made nearly as deep as the side frames *a*, and their upper flanges are connected to those of the inner cross bearers *d*, *d* by means of an horizontal plate or bracing *f*, which is also provided with flanges *g* to unite each of its sides to the side frames *a*. The lower flanges of the deep cross bearers *c* and of the side frames *a* are united by diagonal bracing *h*. In the case of motor bogies the cross bearers *c*, *d* are connected in pairs by means of diaphragms or gussets *i* disposed longitudinally and arranged to stiffen the outer cross bearers *c* immediately at the back of the bracket arranged to support the nose of each motor. The space between the outer cross bearers *c* and each headstock *k* is then available

for the reception of the motor and its gearing. When it is not necessary to provide space for machinery, the outer cross bearers *c* and the upper flange bracing are constructed in lighter fashion, as shown in the right hand half of fig. 2, that is to say, the bearers *c* are connected to the headstock *k* by means of bracing *l* in the form of the letter A, thus providing for the suspension of central brake rigging. Each leg of the brace is connected by means of a gusset plate *m* to the cross bearers *c*, *d* and to the side frame *a*, the plate thus stiffened forming a suitable attachment for the support of brake blocks. Owing to the special construction of bogie described, it is convenient to arrange vertical levers *n* at each side between the outer and inner transoms, each pair of levers *n* having their fulcrums pivoted on a cross beam or shaft *o*, which also carries at each end a push rod or pair of push rods *p*, acting upon the inner brake block *q* of each tyre *r*. The lower extremity *s* of each vertical lever *n* is connected by a pull rod *t* to the end of a similar vertical lever *v* pivoted near the end of a cross beam or shaft *w*, each end of which carries a brake block *x* to act on the outer face of each tyre *r*. The upper ends of the levers *v* are connected by pull rods *y* to links *z*, which latter are also connected to one pair of levers *n*, and by means of rods 2 to a yoke 3, upon which the main central pull rod 4 acts. A laminated bearing spring 5 is employed for each axle box, having hangers, preferably with auxiliary springs bearing against brackets 6, the inner pairs of which are arranged to support the hangers of an inverted spring 7 at each side. The buckles 8 of the latter springs are provided with spring links 9, supporting at their lower ends a bolster spring beam 10, which passes transversely beneath the main frames at the centre. The buckles 8 are so guided as to be capable only of vertical movement with respect to the frames. *(Accepted 19th December, 1907.)*

Draught Excluder for Carriage Windows. 23,027. *18th October, 1907. F. W. Beresford, of James Beresford and Sons, Cato Street Works, Birmingham.*

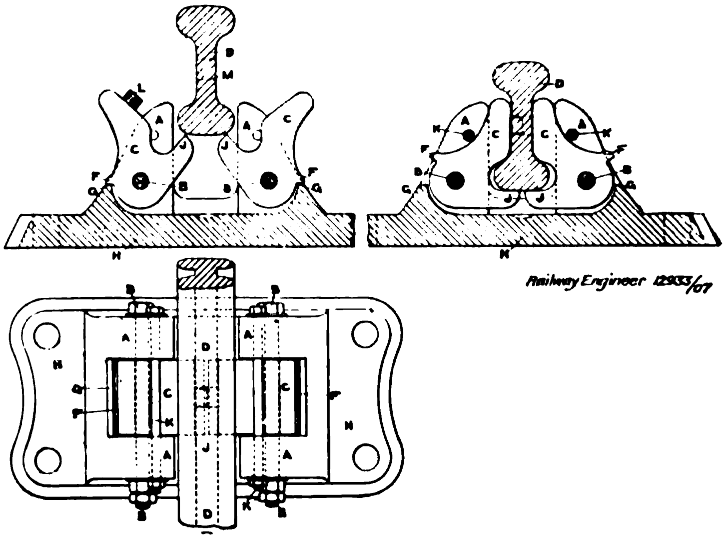
The sash is fitted with a device D which acts as an anti-vibrator and draught excluder. Such device comprises two hinged strips *d*, d^2, the former being drilled with a set of holes for receiving screws or other means for securing it in the desired position, while the latter is bent over slightly at the edge for forming a surface for bearing against the window. At each end of the flap d^2 are small rubbing pieces



d^4 bearing against the side edges of the window. These rubbing pieces may be made of rubber or other material suitable for absorbing shock and preventing scratchings of the woodwork forming the side edges of the window. The flap device D is arranged on the inside of the garnish rail G of the door as shown at fig. 1, with its bent over flap d^2 bearing against the window W. When the window is raised and over the fence w^1 the flap d^2 is firmly pressed against the lower edge of the window, thus closing the aperture at the top of the window recess g^1 in the door. As the window is lifted off the fence w^1 and lowered or partially opened, as at fig. 2, the flap d^2 bears against the side of the window and keeps the same against its guides, thus preventing annoying rattle and noise caused by the vibration of the window during motion. *(Accepted 19th December, 1907.)*

Rail Chair. 18,933. *22nd August, 1907. S. Wheelhouse, 60, Wood End, Hebden Bridge, Yorkshire.*

The chair is formed with two fixed jaws A upon each side and a pivotted jaw C between them. When inserting a rail the loose jaws are turned back upon their pivots, until arrested by the stops or projections F. Upon placing the rail in the chair it is lowered between the fixed jaws A, and coming in contact with a projecting heel or wing J of each loose jaw C, automatically tilts the latter forward until they come in contact with the sides of the rail. The wings J being now brought into position, serve as a support or bear-

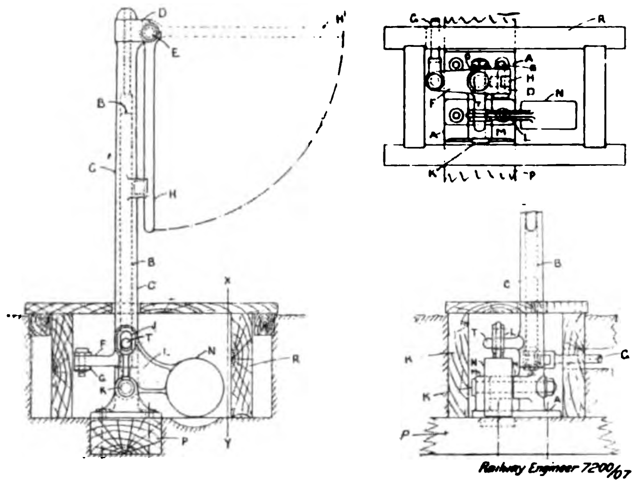


ing for the rail, which is also shared by the loose jaws, so that the more weight put upon the rail, and by the rail upon the wings J, the greater the nip or grip of the loose jaws upon the sides of the rail and the more rigid it becomes. The loose jaws C are secured in position after the insertion of the rail by cotters, pins, or bolts K passing through the fixed jaws A, A, and behind the loose jaws C; in this manner the rail is securely fixed within the chair. To prevent undue lineal movement of the rails and allow for expansion or contraction of same, a stud L is formed upon one of the loose jaws, which, when the paws engage with the rails, fits within a similar recess M in the rail. *(Accepted 12th December, 1907.)*

Shunting Levers. 7,200. *26th March, 1907. J. R. Peacock, 43, Radford Boulevard, Nottingham.*

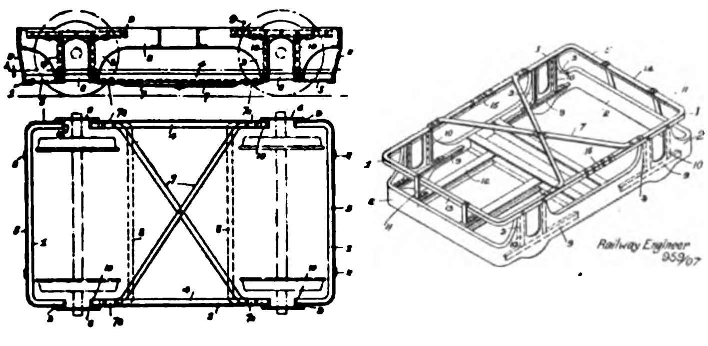
This shunting lever is intended to enable the points or switches to readjust themselves automatically in the event of an engine or train being run backwards through the points. A base plate A is fitted with a vertical spindle B, upon which turns a hollow pillar C having at its upper end a handle H hinged thereto at D by pin E. This handle when not in use hangs down out of the way, but when the shunting lever has to be operated it is raised to a horizontal position. Near the bottom of the pillar C is a lever F, to which is pivotted one end of the point rod G, the other end of same being connected to the switch rails to be operated. An arm or stud T attached to or formed on pillar C works freely in a slot J formed in the upper end of the bell-crank lever L, which in turn is fulcrummed by the axle K from the bearings M M. The other end of the bell-crank lever L has a balance weight N, formed sufficiently heavy to retain the switch rails in one

normal position, but capable of allowing them to be opened without damage, should a train or the like be run backwards through the points. When it is required to reverse the switch, the pointsman lifts the handle H to the horizontal



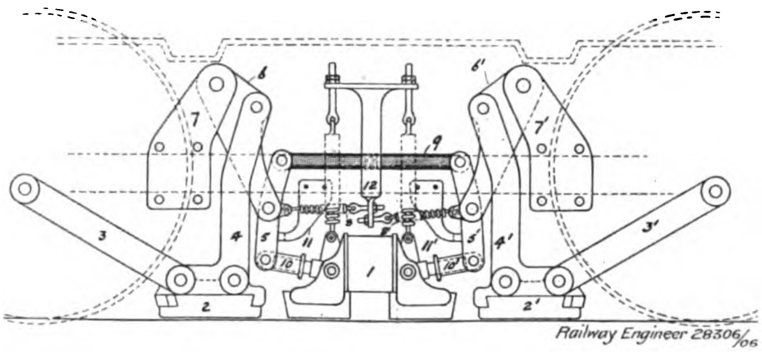
position H[1], and by this handle partially rotates the pillar C, and with it the lever F; this in turn actuates the point rod G and the switch rails connected to same, which are thus thereby reversed. *(Accepted 12th December, 1907.)*

Bogies or Trucks. *959. 14th January, 1907. J. A. Panton, 42, Ashdale Road, Waterloo, Lancaster.*
In order to prevent distortion and lateral play of the truck or bogie frames of railway and tramway vehicles, a supplementary underframe or bracing is applied to such frames. The frame or bracing 1 extends round the truck 2 and is disposed on the level of the lower extremities of the horn plates 3 to which it is attached. This underframe comprises two side bars 4 connecting the two inner horn plates on each side of a four-wheeled truck, and two end bars 5 disposed at the ends of the truck and connecting the outer horn plates on one side of the truck with the outer horn plates on the other side of the truck, these end rods 5 being bowed or curved outwards to pass in front of the wheels and so as to be well clear of the wheel flanges. The extremities of each pair of horn plates



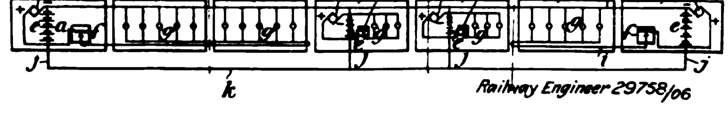
are connected by the usual bar 6, which is detachable for the purpose of removing the truck from its wheels. Diagonal cross stays 7 extend from one side of the underframe to the other, the extremities of these stays being attached at 7[a] to the frame 1 close to the ends of the horn plates. Or transverse stays 8 may be employed in lieu of the diagonal stays as indicated by dotted lines in fig. 2. The inner horn plates of the truck are thus braced together by a rigid frame comprising the side rods 4 and the diagonal cross stays 7 or transverse stays 8. Passing up each horn plate and attached thereto and to the bars 9 at the crowns of the horns are angle bars 10 which are preferably, in this type of underframe, integral continuations of the end bars 5 or the side bars 4, but may be separate angle bars if desired. The vertical bars 10 serve therefore to rigidly connect the bars of the underframe 1 with the bars 9 above each pair of horn plates. The end bars 5 of the underframe are suspended by straps 11 from the ends of the truck of the short longitudinal girders 12, as shown in fig. 5. *(Accepted 28th November, 1907.)*

Brakes. *28,306. 12th December, 1906. A. W. Maley, 7, Harehills, Leeds.*
This invention consists in employing with the usual brake blocks 1, acting upon the track, an auxiliary track block or blocks 2, 2[1], and causing the latter to be operated by the drag of the main blocks. The blocks 2, 2[1] are connected by links 3, 3[1] with the axle boxes or any convenient part of the car frame. Thrust rods 4, 4[1] are also connected with the blocks 2, 2[1] and to bent levers 6, 6[1], which latter are pivotted at their upper ends to the main brackets 7, 7[1], the latter



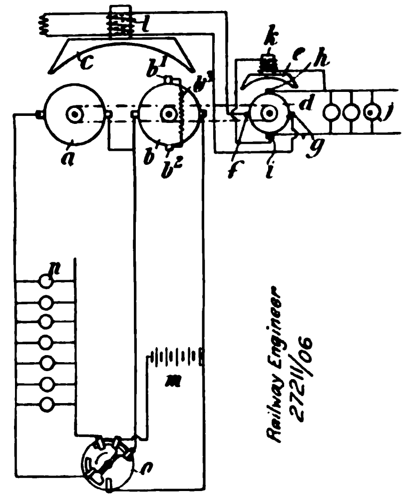
being firmly bolted to the car frame. The lower ends of the bent levers 6, 6[1] are pivotted to the floating levers 5, 5[1], whose upper extremities are attached by pins to the common rod 9, and whose lower ends are pivotted to the telescope rods 10, 10[1], which latter are attached to the main track-block. Tension springs 8, 8[1], which extend from the hanger 12 to the lower ends of the bent levers 6, 6[1], serve through the bent levers and thrust rods to raise the auxiliary track-blocks from the rails when the brake is to be released. Stop brackets 11, 11[1] limit the movement of the lower extremities of the floating levers 5, 5[1] in an inward direction. *(Accepted 12th December, 1907.)*

Electric Lighting of Trains. *29,758. 31st December, 1906. H. Leitner, Maybury, Woking, Surrey.*
Train lighting systems in which single coaches or groups of coaches have independent generating and storage equipment are so arranged according to this invention that each generating coach, whilst supplying the lamps of its own group, can also supply the lamps of the other groups without interfering with its own independent regulation. In the example illustrated the batteries *e*, *e*, *e* of the different groups *a*, *b*, *c* are connected by the connections *j*, *j* to a line or cable *k*, and with this arrangement it will be seen that the lamps *g*, *g* in each of the three groups can be lit from any one or more of the generating plants of the groups which are mutually helpful. The line *i* in the two end groups



of coaches is doubled back upon itself in order to make up for line drop in the well-known manner. Resistances may be introduced into the connections *j* between the batteries and the line wire *k* in order to compensate against any excessive surging. The connections *j*, *j* between the mains of the adjacent groups of coaches can, in cases where a system of through control from the guard's van for the whole of the lights throughout the train is employed, be advantageosuly made up in the same cable as that carrying the control wires. Or these connections may be carried in the cable consisting of the bell, telephone or like wires. *(Accepted 31st December, 1907.)*

Electric Lighting of Trains. *27,211. 29th November, 1906. H. Leitner, Maybury, Woking, Surrey.* This invention relates to a variable speed generator self-exciting in either direction of rotation, and capable of running on open or closed circuit, furnishing the requisite voltages for charging a battery of accumulators and supplying simultaneously current for a lamp circuit. In conjunction with the main dynamo, which has a double wound double commutator armature represented at *a*, *b*, there is provided a small exciting dynamo *d*, *e*, running synchronously with the main dynamo and preferably mounted on the same shaft. The exciting dynamo *d*, *e* has a field of great remanence, and is furnished with main brushes *f*, *g* in a line at right angles to the line passing through the pole centres. The exciting dynamo is also provided with the subsidiary brushes *h*, *i* in a plane at right angles to the main brushes *f*, *g*, these subsidiary brushes *h* and *i* being connected to an adjustable circuit or resistance, in this case in the form of a lamp circuit *j* which is of negative temperature co-efficient and of constant



value. This resistance *j* balances the whole of the system and has connected up in parallel with it the shunt winding *k* which excites the field *e* of the subsidiary dynamo and is the only winding which is necessary in that field. The brushes *f* and *g* excite the field *c* of the main dynamo by the winding *l*. Subsidiary brushes b^1, b^2 are in connection with the armature *b*, are connected by the resistance b^3 and serve to compensate for variations in the battery charging circuit. An automatic cut-in and cut-out switch *o* puts the battery *m* and lamp circuit *n* respectively in connection with the main circuit of the dynamo. The field *c* will be excited by the winding *l* with diminishing voltage proportional to the speed at which the train is running. The lamps *n* are then supplied with current from the armature winding *a* and the battery *m* simultaneously charged from the armature *b*, any excessive current being checked by the armature reaction set up through the adjustable resistance b^3. When the train stops the switch *o* is automatically operated so as to disconnect the lamps *n* from the armature winding *a* and the battery *m* from the armature winding *b* and to connect the lamps *n* with the battery *m*. *(Accepted 29th November, 1907.)*

COMPLETE SPECIFICATIONS ACCEPTED.

1906.

19737. Signalling systems for railways and the like and apparatus therefor. British Thomson-Houston Co.
27211. Systems of electric train lighting. Leitner.
27593. Electrical communication between guard and driver, warning them of the opening of doors whilst in transit. Crepin.
27932A. Railway and tramway axle-boxes and the like. Demolder.
29170. Couplings for railway carriages. Wegner.
28040. Locomotives. Boult.
28306. Brakes for rolling stock of railways and tramways. Haley.
29072. Electrically-operated railway and like signals. Brown.
29758. Systems of electric train lighting. Leitner.

1907.

1032. Automatic Couplings. Shailer and Sulley.
1481. Pulleys for carrying railway signal wires and like purposes. Williams, Williams and Williams.
2468. Fog signalling apparatus. Deighton.
2973. Method and means for actuating electro-mechanical fog signals for railways. Lowthian.
5103. Apparatus for preventing accidents through corves or the like railway or tramway vehicles breaking loose or running away on inclines. Hargreaves.
6134. Signalling systems for railways and the like. British Thomson-Houston Co.
6262. Brake mechanism for tramway and like vehicles. Spencer.
7200. Means or appliances for operating railway and tramway points and the like. Peacock.
9437. Semaphore signals. Abernethy and Weiss.
9438. Semaphore signals. Abernethy and Weiss.
15013. Valve-gear for locomotives. Lentz and Bellens.
16368 Supporting guides or antifriction rollers for the operating rods of railway switch points and the like. Kershaw, and Saxby and Farmer, Ltd.
17699. Apparatus for operating railway and like points and switches. Kershaw, and Saxby and Farmer, Ltd.
18498. Operative system for electric locomotives. Böhm.
18501. Means for securing railway and other rails to sleepers. Hosking.
18592. Bogies for railway vehicles. Sheffield and Twinberrow.
18820. Railway couplings. Hopley.
18933. Railway chair. Wheelhouse.
19137. Railway rail-joints and supporting devices. Carroway and Crews.
20103. Railway rail chairs. Marshall and Penman.
22618. Joints for railway and tramway rails. Whitaker and Whitmore.
23027. Railway carriages and other windows. Beresford.
23983. Insulating end post for railway rail joints. Karns.

Distribution of Current to Trains on Electric Railways.—V.*

SINGLE phase alternating currents are being introduced into railway work, and with considerable success, but the motors employed are the ordinary series wound continuous current motors, with special arrangements enabling them to be employed with single phase alternating currents, and to work efficiently with them. There is not space here to explain the details of the construction of the single phase continuous current motor, but it may be mentioned that the arrangement consists principally in tapping the coils of the armature, at points at the end of a diameter, connecting the tappings to insulated rings fixed on the armature shaft, against which collecting brushes bear, the apparatus then responding as a motor, either to continuous currents delivered to the commutator, or to alternating currents delivered to the insulated rings at the back. Further apparatus are added to the windings, enabling the motor to be worked efficiently. One of the advantages of this arrangement that has been made use of in America is, the motors when fixed to locomotives, are enabled to work with single phase currents, say on a railway inter-urban line, and to work with the ordinary continuous currents employed usually on ordinary urban railways.

The electro magnetic induction that has been mentioned above leads to other serious matters in connection with the return current. Thus, if the iron rails were employed to carry the return currents only, the loss of power in the rails would be very heavy, owing to the induction created in the rails themselves by the alternating currents. Another peculiar feature in connection with alternating currents, when passing through solid conductors, is, the passage of the current is confined to the skin of the conductor, and this practically means that the conductor itself is of smaller value

*No. I. of this series appeared in the *Railway Engineer*, August, 1907; No. II. in October, 1907; No. III. in December, 1907; No. IV. in February, 1908.

than if it was carrying a continuous current, or, to put it in another way, it has a higher resistance. Any solid conductor may be looked upon as a bundle of conductors of very minute section, and when an alternating current passes through the conductor, it may be taken to split up between the conductors forming the bundle, and as each current

Fig. 17. Strain Insulator for Steel Supporting Cables of Overhead Conductor.

passing in each minute conductor acts inductively upon all the other conductors, the result is that which has been described. In small copper conductors, carrying currents of small strength, the effect is negligible, but with large copper conductors, carrying large currents, the effect may be to practically reduce the conducting power of the conductor as much as 2/5, and with iron conductors the effect is very much increased by the magnetic action of the iron itself. In addition, all the troubles that have been mentioned in con-

Fig. 18. Strain Insulator.

nection with the joints of the rails, the bonds, etc., would be considerably accentuated. Hence it becomes necessary, where single phase currents are employed in railway work, to fix special return conductors, which must be of copper, or the equivalent; and again, they must be connected to the track rails, because the alternating currents that are constantly surging to and fro, in the return conductor, would induce currents in the track rails, in the manner that has

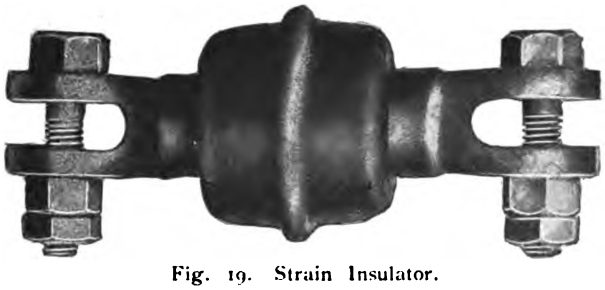


Fig. 19. Strain Insulator.

been described above, these currents absorbing a considerable amount of the power delivered to the circuit. An instance that will illustrate this may be mentioned. In the early days of electric lighting of towns, when single phase alternating currents were employed, the separate conductors of a single phase service were carried independently, in separate iron pipes, with the result that the pressure delivered to the service was reduced so much that the service itself could not be carried on, currents induced in the iron pipes absorbing a large portion of the pressure. In the case of the railway track, the difficulty is overcome to a very large extent by bonding the return conductor to the track rails, and to all iron work, and the bonds should be as frequent as possible, so that any induced currents may be damped down.

Delivering Single Phase Currents to the Trains.

It will be understood from what has been said above that it would be practically impossible to employ third rails for single phase currents, the difficulties created by induction would be too serious. In addition to this, as one great object in employing single phase currents is to use higher pressures, it will easily be understood that the space available on the track hardly permits of much higher pressures than

Fig. 20. Section of Strain Insulator.

those already in use with continuous currents. Hence, single phase alternating currents are delivered to the trains by overhead conductors. The overhead conductor is very similar to that with which everyone is familiar on our tram lines, but it has to be in the majority of cases heavier, and therefore requires more frequent supports. As also inter-urban railway lines are often in exposed positions, increased mechanical strength of support is necessary. It will be understood that the overhead conductor must be insulated from everything but its own feeder cables, in the same way as the track conductor is, and as the pressures employed

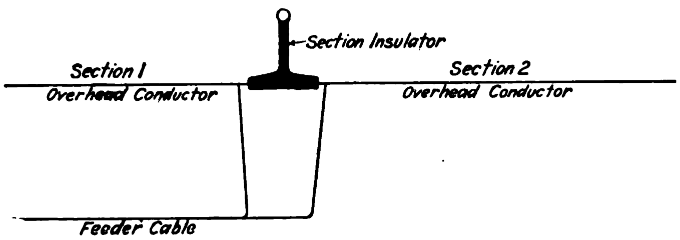


Fig. 21. Diagram showing connections between Feeders and Overhead Conductors at Section Insulator.

with single phase currents are so much higher, the insulation must be higher in proportion. Practice has settled down to one system. Iron or steel pillars are fixed on each side of the line, and steel cables are stretched between them, the cables being insulated from the steel pillars by insulators, specially designed for the purpose to stand the necessary mechanical strain. Examples of these are shown in figs. 17, 18 and 19, and a section of a strain insulator showing how the insulating substance is compressed under the strain in fig. 20. The overhead conductor is suspended from the steel cables, also by insulators, again specially designed to stand the necessary strains produced by the collectors, and also those produced by changes of temperature, these latter being very severe in some parts of the world, as in parts of America and Canada. The insulators employed are made of special material, that has been gradually evolved. Lava is a favourite substance and some others. The strains upon the overhead conductor, and upon its insulators, it will be understood, are different to those upon the track conductors. The col-

lector on the locomotive passes necessarily under the overhead conductor, and pushes it upwards, and the whole arrangement, the steel cables, the insulators, and their supports, are designed to meet these strains, in such a manner

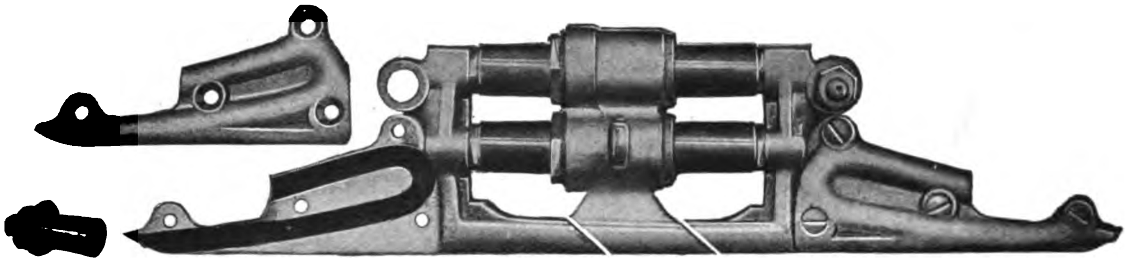


Fig. 22. Section Insulator for Overhead Conductor.

that the conductor resumes its position immediately after a train has passed, ready for the next one.

The railway to be supplied with single phase currents is divided into sections, just as described with continuous currents, and between any two sections, what are called section insulators are fixed. The overhead conductor is broken at the section insulator, and the feeder cables are brought to the pillars joining the section insulators, and are there connected to the two sections. Thus, the collector on the train receives current on one section from the overhead conductor of the section, and when it reaches a section insulator it momentarily ceases to receive current, while it is passing over the section insulator, the next instant receiving current from the overhead conductor of the next section. Fig. 21 shows the arrangement, and figs. 22, 23 and 24 show forms of section insulators. It will be seen that this arrangement enables any section to be isolated in which there is a fault, so that tests can be made, and the fault discovered. Everyone will be familiar with the wink in the lamps of a town electric tramcar from time to time. These winks are nearly always caused by the trolley pole passing under a section insulator.

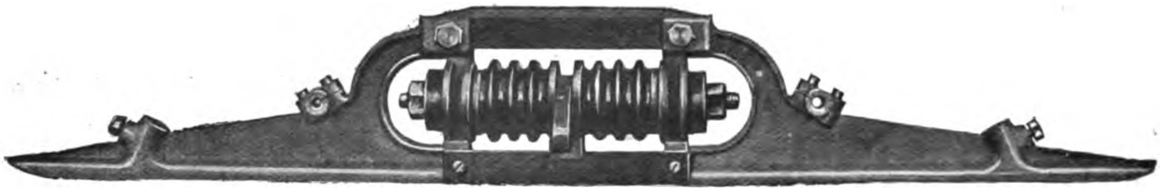


Fig. 23. Section Insulator.

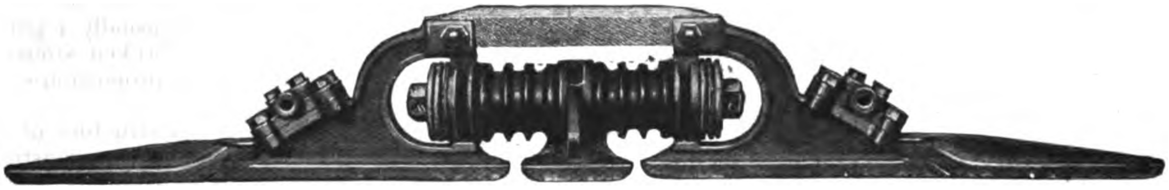


Fig. 24. Section Insulator.

The current is delivered to the overhead conductor by feeder cables just as with continuous current distribution, but the feeders may receive their current from sub-stations, as explained in connection with continuous currents, or, as is more frequent, where the area of distribution is large, the currents may be carried by the side of the line, at very high pressures, say 10,000 or 20,000 volts, and be transformed down at convenient positions, by transformers carried on poles, if necessary, or in small buildings arranged for the purpose, to the working voltage of the system, say, 3,000 volts, the feeder conductors being taken from the transformers to right and left to feed the different sections. Fig. 25 shows this. For cross country work the high tension cables and the feeder cables may both be naked conductors, carried on insulators, on poles by the side of the line, the connections being made to the overhead conductor at the section insulators by covered conductors.

As explained above, the current may be taken direct to the motor on the locomotive at 3,000 volts, or as is frequently arranged, it may be transformed on the locomotive by transformers carried there for the purpose, to a lower voltage, and delivered to the motors at the lower pressure, as shown in fig. 26. The actual pressure at which the current is delivered to the motor is a matter for the judgment of the engineer, and will be determined by the conditions of the ser-

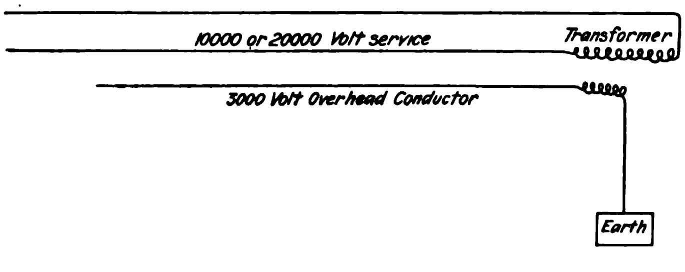


Fig. 25. Diagram showing connections for delivering Current to Overhead Conductor from High Pressure Service.

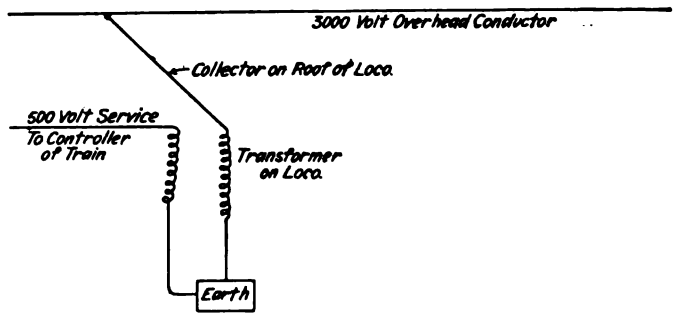


Fig. 26. Diagram showing connections for Transforming 3,000 volt Overhead Service to 500 volt Loco. Service.

vice. If the locomotive is to run over a city line, and to use continuous currents there, while it uses single phase currents outside, the pressure to which the single phase currents are reduced will be the alternating equivalent of the city service. Where the locomotive has only to work over cross-country lines, where the full pressure can be employed, this will not be necessary.

The New York Rapid-Transit Subway.*

THE population of the City of New York is about 4,150,000, distributed among five boroughs. The railway described in this Paper is confined chiefly to the borough and island of Manhattan, the most important district of the city. The railway has been constructed by and at the expense of the Municipality, under the jurisdiction of the Rapid Transit Commission, through two contracts with one company. These contracts provided that the company should construct the railways for a lump sum in each case, payable in cash by the city as the work progressed; that it should furnish all equipment, to be taken over by the city on an appraised value at the termination of the leases, and to operate the railways for 50 years with the renewal period of 25 years. The rental during the first period is the interest on the city's bonds issued for the construction, plus 1 per cent. per annum for a sinking fund. For the second period the rental is to be fixed by arbitration.

The material through which the railway has been built is chiefly a mica-gneiss rock and sand.

The route begins at one of the suburban stations of the Long Island R., in the borough of Brookyln, passes under streets in that borough for 1½ mile, and thence in tubes under the East River, whose width at the point of crossing is nearly 1 mile; it then follows a central route under streets in Manhattan for about 8 miles, where the line forks, one branch continuing north, the other north-east to the upper part of the city in the borough of the Bronx, giving a total length of route of 25·7 miles.

It was in 1894 that the Rapid Transit Commission was appointed and the work projected; but for various reasons the latter was not begun until 1900. Contract No. 1, covering about 21 miles, was completed in 1904; and contract No. 2, executed at the close of 1902, and involving the slow work of subaqueous tunnelling, has recently been put in operation. The question of type involved much labour in consideration, great effort being made by many people and some newspapers to have New York follow the lead set by London in tube construction. The author, as chief engineer to the Commission, after a study of the tubes in operation and under construction in London, advised that the converse extreme principle in design be adopted, and that so far as possible the railway be of "subway" rather than tube type, and be kept as close to the surface as local conditions permitted.

In New York, the demand for additional transportation, especially for long distances, was so great that the two tracks were recognised as being too few to carry the traffic, and especially to give the required high speed. It was therefore decided to construct four tracts, parallel, and usually on the same level, over the central section, where the traffic would be the heaviest, on which trains could run all day in both directions. The outer tracks were to serve the local traffic, with about four stations to the mile, while the inner tracks were to carry the fast service, with stations at intervals averaging 1½ mile. On the sections where traffic would be less heavy, three tracks were projected, the central one to give an express service in the direction of maximum demand; that is, towards the commercial district in the morning, and from it in the evening. Of the total route, 10·2 miles have two tracks; 7·6 miles, three tracks; 7·6 miles, four or five tracks; 0·2 mile, eight tracks, a storage yard; and 0·1 mile, one track, a terminal loop.

*Abstract of a Paper by W. Barclay Parsons, M.Inst. C.E., read before the Institution of Civil Engineers.

To support the street roadway, a flat roof was adopted, consisting of transverse beams set at 5-foot spacing. As the result of careful investigation, it was found to be more economical to support these beams on rows of columns between the tracks, without any longitudinal girder. Construction was also facilitated by such design, as the individual members were thus made light in weight, and were limited to few varities. The roof beams at the side rested on I beams in the walls, and wherever there was an upward hydrostatic pressure, transverse beams were embedded in the floor. There was thus formed a frame of steel members capable of taking all the stress. Between the beams was moulded concrete.

From the surface of the paving to the top of the roof the minimum distance is 30 in., governed by the yokes of the surface electric tramway. The height in the clear from rail-level to underside of roof is 13 feet, and the width per track is 12 feet 6 inches. The internal diameter of a tube of corresponding capacity would be 15 ft. 6 in. This accommodates a car similar to the one in use on the New York elevated system, and much larger than any car in the London tubes, except the Great Northern and City. The minimum depth from street to rail-level is 17ft., and to platform about 13ft. Every effort was made to attain this last dimension at stations.

In order to keep the subway dry, an envelope of waterproofing material was embedded in the concrete of floor, walls, and roof. This material was alternate layers of paper roofing-felt and carefully selected asphalt. This envelope was made continuous, and was protected from subsequent external injury by an external covering of concrete. This was found to work well against even a substantial hydrostatic pressure. Where, however, such pressure became considerable, layers of bricks, dipped in asphalt, were used instead. The concrete was mixed very fluid, in order to secure as tight work as possible, irrespective of the waterproofing. Its proportions were usually 1 part cement, 2 of sand, and 4 of gravel or fine broken stone, except where used in large masses, when the proportion of the aggregate was increased.

After the work had begun, a structure of reinforced concrete was designed instead of the beam construction, and has been largely used. The rows of columns between the tracks are retained, and, in order to economise space such columns are of steel. A longitudinal truss of reinforced concrete connects the columns, while the roof and walls contain rods on the tension side. Wherever below the level of standing water, rods were embedded in the floor. Such construction, in practice, was found to be both cheaper and more expeditious than beam construction.

Although the basis of the design is a shallow subway, with a flat roof, and constructed by "cut-and-cover" methods, there was no hesitation to depart from this type if conditions demanded or warranted such a course. There are 14·2 miles of cut-and-cover of which 13 miles have a flat and 1·2 mile an arched roof, 3·9 miles of masonry-lined tunnels, 2·7 miles of iron tubes and 6·6 miles in the open or on steel viaduct. The total mileage of types is greater than the route mileage, as some of the tunnels, notably the tubes, are separate structures for each track. All kinds of construction are thus embraced in the New York railway. In building the tubes compresed air was used at as high a pressure as 40 lbs. per square inch.

Stations for the local tracks, except in a few instances where islands platforms were more convenient, have platforms on the outside with short direct stairways leading to the pavement. There are for each platform usually two exit and two entrance stairs. The express stations are served by island platforms, one between each pair of tracks, connected with each other and with the street pavements by an overhead bridge. At such stations passengers can transfer freely and without extra charge from local to express trains and

vice versâ. Such transferring is done to an unexpected extent, the local trains acting as gatherers and distributors for the express trains. The express trains are scheduled to make about 30 miles per hour, and the locals 13 miles.

There are 58 stations, of which all but four are reached by stairs only, while of the four, three have lifts, and one a moving staircase working in both directions.

Junctions are arranged so that opposing tracks pass under and over, there being no level crossing. The sharpest curve where speed is possible has a radius of 458 feet, and the maximum gradient is 1 in 33, or less than 1 in 60 if accelerating is likely.

The express tracks are wholly and the local tracks partly protected by automatic block signals, with emergency automatic stops. The permanent way is of the usual American standard with 100-lb. rails.

The shallow subway required a very thorough reconstruction of the sub-surface structures, accomplished at times by drastic measures. The sewers required the most care, 17 miles of new sewers being built, varying in size from 12in. pipes to 15ft. diameter brick structures.

All materials were purchased after close inspection. Elaborate investigations were made into the quality of cement, and the physical properties of concrete, both plain and reinforced, and the effect of paint or other coating of the embedded rods. This was essential on account of the large quantity of concrete used, namely, 725,000 cubic yards, and 1,320,000 barrels of cement.

The cost of the railway, 25·7 miles long, with 76·3 miles of track, was about 50,000,000 dols., exclusive of equipment, interest during construction, or easements; the equipment added about 25,000,000 dols.

Results of operations have been very gratifying. During the fiscal year ended June 30th, 1907, on 21 miles, the line to Brooklyn not being open, over 166,000,000 passengers were carried. The current year is showing a considerable increase, exclusive of the Brooklyn traffic, which since January 1st, 1908, adds still further to the total. The fare is 5 cents. (2½*d.*), regardless of distance.

The Author is of the opinion, *inter alia*, that the cost of shallow construction does not exceed deep-tunnel construction, unless the former is burdened by heavy charges for vault easements; and that the success of the New York subway is due to the high-speed service and the convenient arrangement of the stations with their short direct means of access.

Official Reports on Recent Accidents.

At **Bamber Bridge Station, L. & Y.R.** *On the 30th November. Lt.-Col. E. Druitt, R.E., reports that:—*

A special cattle train (4-coupled engine, tender, 9 cattle wagons and van fitted with screw coupling and vacuum brake) from Liverpool to Accrington was overtaken and run into by the 5.55 a.m. express boat train (10-wheeled engine, tender and 7 bogie carriages fitted with vacuum brake) from Fleetwood to Leeds.

The collision was rather severe. The engine of the express was derailed and the guard's van and two rear cattle wagons badly damaged; eight 30-ft. rails bent, 20 chairs broken and 59 sleepers damaged. The guard of the cattle train and the driver and fireman of the express were injured.

Approaching Bamber Bridge Junction signal-box the up line from Preston Junction runs from the north-west and the up line from Lostock Hall Junction from the west. The junction points are exactly opposite the signal-box, and the up line runs thence about due east through Bamber Bridge Station. The signal-box is 35 feet south of the up line, the down line and down loop line being between the up line and the box. There is a very good view from the latter. The up junction home signal for the line from Preston is 120 yards, and that for the line from Lostock Hall (Liverpool direction) 124 yards back from the signal-box. The inner up home signal for the junction box is 215 yards east of the signal-box towards the station, and is common to trains arriving from either Preston or Lostock Hall. There are inner and outer distant signals extending back to over 1,000 yards in the case of the line from Preston and over 900 yards for the line from Lostock Hall. There are distant signals under each of the Junction home signals for the next signal-box in advance, viz., Bamber Bridge Station.

The following is the general rule bearing on this case.

64. (*a*) If, when two or more trains approach a Junction at the same time or at nearly the same time, the Signalman should have lowered or taken off the Signals for a train which should have been kept back for the passage of another, he must not attempt to alter the order of the trains by reversing the signals, but must place them all at Danger, and so keep them until all the trains have been brought to a stand, when precedence can be given to the proper train.

Signalman J. Papworth, in Bamber Bridge Junction signal-box, was offered and accepted the special cattle train from Lostock Hall Junction (the signal-box in rear of the line from Liverpool) at 6.17 a.m., and it was accepted by Bamber Bridge Station, the signal-box next in advance of the junction, at the same time. As soon as Papworth had accepted the cattle train he lowered his junction outer home and inner home signals for it. He states he received the "Entering section" signal for it at 6.26 a.m., and just then received the circuit call for the Fleetwood boat train, as leaving Preston at 6.26 a.m., so wishing to give precedence to the boat train he immediately put his signals to danger against the cattle train, under the impression that it had not arrived at his junction home signal. But the cattle train had evidently just passed the junction home signal by the time it was put to danger, so it came to a stand at the inner home signal, which the driver, J. Branson, found at danger on reaching it; and he states he sounded his whistle in the usual way on stopping. Owing to a goods train shunting on the down loop line adjoining, Papworth did not hear the cattle train pass the signal-box, though driver Branson states he could see Papworth in the signal-box with his back to the front of it, and guard Mawson also states he could see him.

Papworth was offered the boat train from Brownedge crossing signal-box at 6.27 a.m., accepted it at 6.29 a.m., and lowered all his signals for it. He sent the cancelling signal for the cattle train to the station signal-box also at 6.29 a.m., but states he does not remember whether it was before or after accepting the boat train. Accordingly the boat train, running with all signals "off" for it, arrived at about 6.30 or 6.31 a.m., and ran into the rear of the cattle train, which had commenced to move forward slowly as soon as the inner home signal at which it was standing was lowered for the boat train. Fortunately, the latter was running at a moderate speed, owing to the difficulty of seeing the signals in the fog. The driver, J. Moon, did not see the tail light of the cattle train, and had no chance of avoiding the collision.

It will be seen from the above that the collision was due to signalman Papworth failing to carry out Rule 64 (*a*) quoted above, which it was all the more necessary for him to observe owing to the fog prevailing at the time, as he could not see where the cattle train was. The tail lights were about 100 yards from the signal-box when the train was standing at the inner home signal, and therefore invisible from the signal-box.

But guard Mawson, of the cattle train, should have gone to the signal-box to remind the signalman that the train was standing at the inner home signal, in accordance with the Rule 55A, as the evidence shows that the cattle train was standing there nearly five minutes. Had he done so after waiting three minutes or so, he might have been able to warn the signalman just in time for him to throw the outer home signal to danger, and he would not have been injured by the collision.

Fogmen were not on duty at the time, though at the actual time of the collision the fog was sufficiently thick to warrant their being called out. The decision as to whether fogmen should be called out is usually left to the signalmen on duty, as they can best form an opinion as to whether they are required or not. In this case the fog appears to have suddenly increased in density just before the collision, and Papworth says he intended to ask for them as soon as the boat train had passed, and he had a free minute or two to do so. They actually did come on duty shortly afterwards. Had fogmen been on duty possibly the accident might have been avoided, as a man is detailed to work under the instructions of the signalman to watch tail lights, etc.

The question arose during the enquiry as to the necessity of assistance being given to the signalman at Bamber Bridge Junction signal-box. The tour of duty is for eight hours, and during the summer months a booking lad is provided during the day, but not during the night. In the winter months, when a large number of trains are withdrawn, the booking lad is not provided. As this case happened before 8 a.m. the booking lad would not have been on duty, even if it had occurred during the summer months. But in view of the large amount of telephone work in this signal-box, and of the general increase in traffic of late years at it, the Co. might consider the question of providing assistance at it, as it is at an important junction.

Papworth is a signalman of long experience, and with an excellent record. He had been on duty just ½ hour, after an interval of 10 hours.

At **Victoria Station, Manchester, L. & Y R.** *On the 24th December. Lt.-Col. E. Druitt, R.E., reports that:—*

The 8.26 a.m. passenger train (6-coupled radial tank-engine and 5 bogie coaches fitted with the vacuum brake) from Middleton was turned on to No. 14 bay platform road by mistake, and ran into some empty vehicles.

A guard and the fireman and guard of the Middleton train were slightly injured.

The traffic into the bay platform roads at Victoria Station is controlled from the Turntable and the Bays signal-boxes. From the former, which is situated about 50 yards outside the platforms, all the points are worked and also the signals for entering the various roads, but as there is a large overbridge between the signal-box and the platforms, the signalman is unable to see if any of the platform roads are occupied by a train or carriages. The Bays signal-box is situated 60 yards inside the entrance to the station and about 110 yards from the Turntable box, on No. 6 platform in the middle of the bay platform roads, and the

duty of the signalman is especially to see that the platform road on which a train is offered to him is clear before he accepts it. He controls the signals for entering each road by an electric slot on them. These signals are just adjoining the Turntable box. Some special arrangements are used for signalling the arrival of trains in these bay roads. The usual bell signals are exchanged, but instead of the usual block instrument, an indicator is provided in the Bays box which shows, by a needle pointing to the number, on which road the signalman at the Turntable box intends to let the train in. Also for each road an electric switch is provided, by turning the handle of which the signalman can either release the home-signal, or the calling-on arm for that road. The signalman in the Bays box has nothing to do with the departure of trains from these platforms, this is entirely controlled from the Turntable box.

The morning was very foggy and the trains were running out of their proper course.

The collision was chiefly due to Oldham's neglect to carry out the duties for which a signalman at the Bays box is alone provided, viz., to see that any particular platform road is clear before he accepts a train to run into it.

Owing to the fog he was unable to see on this occasion if No. 14 road was clear or not; but he was provided with a look-out man, G. P. Harland, who was standing at the time on the platform adjoining his signal-box, and as he could not see himself it was his duty to send Harland to ascertain if No. 14 road was clear before accepting a train to run into it, and his neglect to do so caused the collision. He had used Harland several times previously that morning to ascertain if the various roads were occupied or not.

Signalman Boydell should not have answered Oldham's question as to whether No. 14 road was occupied or not, but should have told him to find out for himself, or if Oldham could not do so, then Boydell could have sent his fogman to ascertain if the road was clear. But he states he did not expect Oldham to act on his reply without ascertaining definitely that No. 14 road was clear. He has a most excellent record. The driver could not avoid the collision, as he could only see about an engine's length ahead: the train was only moving slowly.

*

At **Finsbury Park, G.N.R.** *On 9th November. Lt.-Col. E. Druitt, R.E., reports that:—*

The 9.48 p.m. train, Moorgate Street to High Barnet, was run into from behind by the 10.5 p.m. train, King's Cross to Muswell Hill. Both trains consisted of a 4-coupled 10-wheeled tank engine and 11 close-coupled 4-wheel coaches with a guard's compartment at each end of the train, fitted with the automatic vacuum brake to the coupled engine wheels and all the carriage wheels. Only the trailing bogie wheels of the engine of the Muswell Hill train were derailed. The driver of the Muswell Hill train was injured and 24 passengers also complained.

The 9.48 p.m. passenger train for High Barnet ran into a thick fog when approaching Finsbury Park on the down slow No. 2 line. The distant signals for No. 3 signal-box, which controls the down lines at the south end of the station, were at danger, and so the train was brought to a stand at the home signal for a moment, and then was admitted into the down slow platform line between Nos. 6 and 7 platforms. It arrived at 10.10 p.m., but had to wait for a North London train which runs into the station on the down Canonbury line on the far side of the No. 7 platform. This train was late, and the High Barnet train was still standing on the down slow line when at 10.15 p.m. the 10.8 p.m. passenger train from King's Cross for Muswell Hill, which was following on the same line, ran into the rear of the High Barnet train, though both the home and distant signals were at danger for the second train.

As the fog was so thick the fixed signals could not be seen, and the drivers had to rely on the detonating fog signals and fogmen who were on duty at the down distant signals for No. 3 signal-box, and at the down distant signals for No. 5 signal-box, the latter being on the same posts as, and underneath the down home signals for No. 3 box.

On passing the distant signals for No. 2 box driver Clarke, of the Muswell Hill train, received a green hand signal from fogman Pearce, who was on duty there, and as no fog signals exploded he concluded that the home signal was "off," and that the road was clear for him to run into the station. He accordingly kept steam on, and says he ran past the home signal at a speed of 20 miles an hour without seeing either signal or fogman, and gradually reduced speed on nearing the station. He was still running 7 or 8 miles an hour when he saw the tail lamps of the standing train a few yards away, and so could not prevent a collision.

Fogman Pearce at the distant signal admits giving the driver of the second train a green hand signal, and states he did so and also removed the detonating fog signals from the rails, because the down slow No. 2 indicator in front of the fogging machine showed "off," and that indicated that the distant signal was "off" for the train. Pearce is positive on this point, and states he looked twice at the indicator and is sure it showed green and not red, though he states it showed red a very short time after the train had passed, when he looked at it again.

When the second train passed the distant signal the first of the two trains had been standing for two or three minutes in the station, and the signalman and booking clerk in the signal-box both say they are positive the home signal was put to danger behind the first train, and the fogman at the home signals, W. Harmer, states he saw the indicator working with the home signal go to danger after the first train had passed, and the distant signal had not been pulled "off" for the first train. It is thus quite impossible for the signalman to have lowered his home or distant signals for the second train, as there is a clearance bar in the platform road on which the first train was standing, and which has to be worked before the home signal can be pulled off after being put to danger.

It would appear that Pearce made a mistake as to what the indicator showed when the second train passed, though it is difficult to understand how he could do so with the indicator right in front of him.

Although driver Clarke was entirely misled by receiving a green light at the distant signal, yet he was not running with sufficient care considering the density of the fog prevailing at the time. He admits he was running fast and that it was quite impossible to see the signals, and yet he ran past the home signals at a speed of 20 miles an hour without seeing either signal or fogman. He exploded two detonators, as he would expect to do even if the home signal was "off" for him, provided the distant signal for No. 5 signal-box underneath it was at danger. The fogman on duty there, W. Harmer, knowing the home signal was at danger, did his best to attract Clarke's attention by shouting, but the train was running too fast for him to be heard. Driver Wright, who was on an engine standing at the home signals on the adjoining line, also popped his whistle to attract Clarke's attention, without result.

Driver Clarke had been driving suburban trains for nearly 15 years and is fully acquainted with all the details of fog-signalling at the various signals and knew there would be a fogman at the home signals. He would have acted with better judgment if he had so reduced the speed of his train by the time he got to the home signal as to have been able to receive a verbal communication from the fogman there, as provided for in General Rule 81 (*d*). Had he done so he would have been warned that the home signal was at danger, and he could have stopped his train before running the 350 yds. to the rear of the other train. Driver Clarke has a very good character and is regarded as a careful driver. He had been on duty 7½ hours. Fogman Pearce also bears an excellent character and is the regularly appointed fogman for the down distant signals for No. 3 signal-box. He had left duty at 1 p.m. in the afternoon and had come on duty again for fogging duties at 8.15 p.m. 2 hours before the mishap.

The fog-signalling arrangements of the Company are fully worked out in every detail, and the fogmen are periodically examined regarding their duties. Pearce had passed a satisfactory examination six weeks previously.

The fogging machines provided at Finsbury Park hold only four detonators. It would be better if a more modern pattern which holds many more were provided, so that the fogman may not have to cross a running line so frequently in order to recharge the machine.

*

At **Dore and Totley Junction Station.** *On 9th October.—Major J. W. Pringle reports that:—*

The second engine and 5 following vehicles of the 1.30 p.m. express from Sheffield to Bristol left the rails. The trailing wheels of the tender of the leading engine were also derailed. The second engine eventually fell over on its left side, and the driver and fireman were injured. Four passengers complained of the shaking.

The leading engine (No. 319), of the 4-4-0 type, and 6-wheeled tender (loaded) weighed 78 tons 2 cwt. 2 qrs. The train engine (No. 1527), 2-4-0 type, and 6-wheeled tender (loaded) weighed 75 tons 3 cwt. 3 qrs. The train consisted of 2 N.E.R. 4-wheeled horse-boxes, each weighing 8 tons, and seven 8-wheeled M.R. coaches and brakes, weighing respectively 26, 25, 23, 24, 26, 28 and 25 tons; total 193 tons.

The engines and tenders were fitted with steam brakes and the train throughout with the vacuum automatic brake, all the wheels being blocked. Considerable damage was done to the permanent way.

This derailment took place at the north end of Dore and Totley Station, on the main line between Sheffield and Chesterfield, where the railway has a general north and south direction. North of the station there are four lines, the western pair being fast lines. South of the station the lines diverge, the eastern forming the main road to Chesterfield, the western to Manchester. The western of each pair of lines is used for down traffic. North of the station there are two double junctions between the slow and fast lines. The most northerly of these junction points are on the slow line. The train was travelling from the up fast line to the up slow line, through the junction crossing, when the derailment took place.

Approaching Dore and Totley Station from the north, the railway is on a very easy left-hand curve. The curvature is slightly sharper on the slow roads, to provide the additional widening between the pairs of lines necessary for the station island platform, which has a width of 36ft.

The site of derailment is 4 m. 10 ch. from Sheffield, where the train commenced its journey. For the first 20 ch. out of Sheffield the line rises at 1 in 330, and afterwards continuously at 1 in 100.

Dore and Totley Station Junction signal-box is situated on the west of both pairs of lines, about 120 yds. north of the station platforms. Measured from this signal-box the approximate distances to the undermentioned places, signals, etc., are as follows:—

	Miles	Chains	
Centre of Sheffield Station	4	10,	north.
Facing points on down slow line at Heeley North Junction	3	0	,,
Millhouses and Ecclesall Station	1	30	,,
Beauchief and Abbeydale Station	0	44	,,
	Yards.		
Up fast home signals for Dore and Totley Junction	162		north.
Trailing points on up fast line (from up slow line)	59		,,
Facing points on up fast line (to up slow line)...	47		,,
Junction trailing points on up slow line	100		south.
Position of overturned train engine after accident...	146		,,

The total length of the junction crossing, from the facing points on the up fast line to the trailing points on the up (Chesterfield) road, is 147 yds.

The curvature of the crossing, commencing at the heel of the facing switches, is as follows:—

1. Left-hand curve, 620ft. radius, 58ft. long.
2. Ditto, 1,200ft. radius, 111ft. long.
3. Ditto, 2,800ft. radius, 98ft. long.
   Tangent, straight, 53ft. long.
4. Right-hand, 1,080ft. radius, 60ft. long.

The superelevation of the outside rail at the heel of the facing switches is $\frac{5}{8}$in. for about 130ft. In the middle of No. 3 curve the superelevation is $1\frac{5}{8}$in. Along the right-hand curve the inner rail is about $\frac{3}{8}$in. higher than the outer rail. This is rendered necessary by the preference given to the left-hand curve on the up slow line.

The facing points of the Junction are fitted with a facing point lock, inside locking bar, 32ft. in length, and proper detecting arrangements. The signalling and interlocking are correct.

The switch rails have a length of 30ft. 7ins., with 18ft. points. There are 14 creosoted sleepers under the switch rails. Of these, two, at the toes, are $9\frac{1}{2}$ft. by 14ins. by 7ins., centred at 2ft. 4ins. apart; eleven are spaced at central intervals of 2ft. 2ins., and measure 9ft. by 12ins. by 6in. The sleeper on each side of the heel joint is 14ins. by 7ins., and carries two single chairs. All the rails used in the crossing are 100 lbs. per yard section.

The evidence of eye-witnesses is conclusive that the second engine first left the rails and was the direct cause of the derailment of the 5 vehicles behind it, and of the trailing axle of the tender in front of it. Also that the derailment took place after passing the facing points.

It is clear from the evidence and facts that the derailment cannot be attributed to the failure, weakness, or want of maintenance of the road.

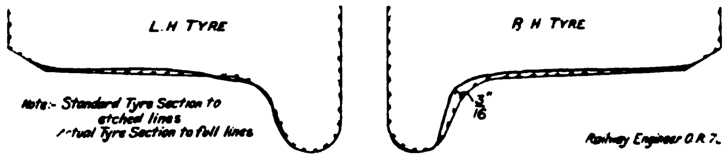
Engine No. 1527 was built in August, 1881; re-boilered Dec., 1891; new cylinders Oct., 1900; in the shops at Derby Sep., 1904; last out of the shops—Sheffield—June, 1906; new tyres on the leading wheels August, 1902; wheels last turned March, 1907. The last monthly examination was made by Foreman Littlewood at Millhouses 29th Sept., 1907. "Wheels good—right-hand leading tyre slightly worn."

The diameter of the leading wheels is 4ft. $2\frac{1}{2}$ins., of the coupled wheels 6ft. $8\frac{1}{2}$ins. When last out of the shops the weights were:—

Left leading, 6t. 4c. 1qr, right leading 6t. 1c. 1qr.
Left driving, 7t. 12c., right driving, 7t. 11c. 3qr.
Left trailing, 5t. 14c., right trailing, 5t. 16c. 2qr.

The leading axle is not pivoted in any way, so that the wheel-base is 16ft. 6ins. The total side play on the leading wheels is $1\frac{3}{8}$ins. The two tenders were identical, each having a wheel-base of 13ft., and an overhang between buffers and trailing axle of 5ft. $2\frac{3}{4}$ins. The length between the trailing wheels of the tender of the leading engine and the leading wheels of the second engine was 11ft. $9\frac{1}{2}$ins.

After the accident the wheels of the leading axle were out of truth $\frac{13}{32}$in. The right flange was considerably worn, as illustrated. The comparatively excessive wear of the right wheel flange shows that some mechanical defect of wheel or frame was in existence prior to the accident.



Tyres of Left and Right Hand Leading Wheels of Engine No. 1527.

By regulation, the speed of all trains over the junction crossing was restricted to a maximum of 20 miles an hour. There is a consensus of opinion of all the witnesses that this train was travelling at the usual speed of through trains, and that it did not exceed the fixed limit of 20 miles an hour over the crossing. It is somewhat unusual to find such complete unanimity of opinion, but it cannot be accepted for the following reasons:—

a. The distance—about 185 yds.—travelled by the train after derailment on a rising gradient of 1 in 100, with the continuous brake applied for at least 150 yds. The second engine ploughed its way over ballast and across sleepers and rails, and four or more vehicles were off the rails for some part at least of the distance. At 20 miles an hour it would be possible, under similar conditions of gradient, to stop a train with no wheels derailed in considerably less distance.

b. The discrepancy in the evidence given by the drivers and firemen as to the place where steam was shut off. The two drivers agree that this was done about 400 yds. from the facing points. Fireman Gray states that the driver's custom was to ease the regulator passing through the Junction, whilst Sargant declares that his driver (Merk) shut off steam at the usual place—50 yds. before reaching the facing points. As a matter of fact, the evidence shows that neither of the drivers entirely closed their regulators, and the continuous brake was not used to check the speed of the train before derailment took place.

c. The driver's estimate for the maximum speed the train attained before reaching Dore and Totley—*i.e.*, 33 miles an hour. Gauged by the times booked for the passing of the train by the various signalmen between Sheffield and Dore and Totley, the average speeds of the train were:—Between Sheffield and Heeley North Junction—$1\frac{1}{4}$ miles, 22 miles an hour; thence to Beauchief—2 m. 28 ch., 49 miles an hour; thence to Dore and Totley—52 ch., 39 miles an hour; between Heeley North and Dore and Totley—$3\frac{1}{10}$ m., 46 miles an hour; over the whole distance—$4\frac{1}{2}$ miles, 35 miles an hour. The booked times, from which these figures are calculated, must not be accepted as accurate, but even if allowance be made for possible errors, the figures tend strongly to show that the maximum speed was higher than 33 miles an hour. The maximum speed would be attained at the moment steam was shut off.

d. The booked time allowed for the train between Sheffield and Dronfield—distance 7 m. 11 ch.—is 11 minutes, over the straight (slow) road. The average speed on the straight road works out from these figures to be about 39 miles an hour. If an additional two minutes be allowed for running over the junction crossings at Heeley North Junction from the slow to the fast line, and at Dore and Totley from the fast to the slow lines, the average speed over the whole distance works out at 33 miles an hour. As far as the south end of Bradway Tunnel—nearly 6 miles from Sheffield—there is a continuous rising gradient of 1 in 100. Over the last mile before Dronfield is reached the gradient changes to one falling at an inclination of 1 in 102. Now, if, as the enginemen admit, the booked timing is generally adhered to, and the speed restrictions to 20 miles an hour at Heeley North Junction and Dore and Totley are obeyed, it is very evident that the maximum speed of trains up this bank must considerably exceed the average speed (33 miles) given by the time allowance. The fact has also to be remembered that the express had started 10 minutes late from Sheffield, and the enginemen would naturally, where no speed limits fettered them, be making what speed they could.

Another contributory cause for this derailment is likely to be found in the coupling of two engines at the head of the train. The second engine, with the comparatively long wheel-base, would find more difficulty in passing round a sharp curve than another with a shorter base. The effect of a worn outer flange, upon which the whole turning movement of a vehicle depends, is much greater in the case of an engine of this type than with one where the turning movement is dependent upon a bogie. The rubbing friction in this case resulting from the worn flange must have been further accentuated by the outward swing of the trailing end of the tender in front of it, especially if the coupling between the two engines was at all tight, and allowed little lateral movement over the surface of the buffers of the two vehicles.

As regards the junction crossing itself, there are several matters for consideration. The radius of the lay out curve at the facing points is about 9·4 ch.; but the actual divergence from the tangent ($4\frac{1}{4}$ins.) of the 18ft. points is equivalent to that on a curve with a radius of about $6\frac{1}{2}$ ch. only. It is practically impossible to provide any considerable superelevation on a junction crossing of this description. It is generally accepted that the limit of speed on a curve should be such that not only will there be no sensible danger, but no possibility of annoyance or apprehension of danger. This will be attained when the action of centrifugal force upon the vehicle does not do more on a curve, having the proper amount of superelevation, than throw it over, by depressing the springs, so that it will maintain its level despite the superelevation. On a 9·4 ch. curve it has been calculated that this effect is attained at a speed of about $19\frac{1}{4}$ miles per hour. But in the first place the superelevation on this curve is only $\frac{5}{8}$in., whereas for a speed of 19 or 20 miles an hour about $2\frac{1}{4}$in. is necessary. Further, the divergence from the tangent of the 18ft. points is equivalent to that due to a curve with a much smaller radius than 9·4 ch. Therefore, in accordance with theory, the speed limit on a junction crossing of this description should not be so high as 20 miles an hour. In practice, as this case indubitably shows, there may very possibly be misjudgment of speed by engine drivers, or there may be failure, even with the best intentions, under bad conditions of rail and weather, to accurately gauge the effect of the brake power. The limit of 20 miles will not, in these circumstances, provide the desirable margin of safety to meet all contingencies.

The fact that during the past 6 or 7 years through trains have daily and hourly passed over this junction crossing, and that no derailment has occurred, does not prove that the conditions are not critical. They must always be critical at such a place. A conjunction of circumstances, each in itself insufficient to cause actual derailment, may, by cumulative effect, bring about this result. In this case there was a higher speed than was justifiable, a worn flange on the leading outer wheel of the engine first derailed, and in front of this engine, which had a long wheel-base, a second engine was coupled, possibly more tightly than usual. It is to the conjunction of these circumstances that this derailment must be attributed.

As regards the observation of speed limits, it is perfectly well known that, in the course of time, unless specific action is continually being taken to check speeds, there is a pronounced tendency on the part of drivers to neglect the strict letter of the law. Provided some action is taken, such as closing the regulator, it is thought that they are sufficiently obeying the regulations. They would not be human if this tendency did not exist. "Familiarity breeds contempt," in the matter of taking risks, is as true of the driver as of the bicyclist or automobilist. It is not, therefore, sufficient to lay down regulations. In the interests of public safety it is the duty of a railway company to ensure that the regulations are rigidly enforced. It may be necessary to this end to fit all engines with speed recorders, or to provide speed tell-tales at all places where speed restrictions are imposed, if they cannot otherwise be enforced.

This particular case calls for consideration by the Co. of the following matters:—

(*a*) Whether the speed restriction at present applicable to junction crossings of this description is sufficiently low to ensure the desirable margin of safety and comfort in travelling?

(*b*) What action is necessary to enforce obedience of speed restrictions?

(*c*) Whether sufficient time is allowed between Sheffield and Dronfield to enable signalmen to strictly obey the speed limits over these junction crossings?

*

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Contents.

THE **Right Hon. Winston Churchill** has succeeded the **Right Hon. D. Lloyd-George, M.P.**, as President of the Board of Trade and the change will not, we fear, benefit railway interests. Mr. Lloyd-George's legal training and experience of the world enabled him to see and appreciate both sides of railway questions which came before him and to be as fair as the policy of his political party would permit. His successor is a young man of 33, who is devoid of commercial training. Mr. Lloyd-George recently said he had found "the ore" [the railway and other interests under the supervision of the Board of Trade] "to be rich and worth working. I just started driving a few adits and levels into the heart of the rock and I was confident of rich results." He did "not doubt that the possibilities of that office will be exhausted to the utmost," by the "skill and ingenuity, courage and resource" of his successor. The prospect of the complete workings is not pleasant to those who have had experience of the bore holes during the past two years so far as railways are concerned.

Sir Robert Harvey, director, has been elected Chairman of the Antofagasta and Bolivia R., in succession to the late **Sir Lepel Griffin.**

Mr. Thos. Blain, assistant secretary, has been appointed secretary and general manager of the Maryport and Carlisle R., in succession to **Mr. Hugh Carr**, who has retired.

Mr. S. F. Johnson, station master at Paddington, and formerly of Windsor, has been appointed district superintendent of the Great Western R. at Birmingham, in succession to **Mr. Edw. Murphy**, who has retired, and **Mr. H. L. Bowles** has been appointed to succeed the late **Mr. J. R. Hankey** as district goods manager at Liverpool.

Mr. A. R. H. Saunders, assistant rating agent, Gt. Western R., has been appointed rating agent in succession to **Mr. P. R. Smith**, who has retired after 50 years' service, and **Mr. F. W. Showers** has been appointed to succeed Mr. Saunders.

Mr. H. Thorpe, of the joint lines account department Great Central R., has been appointed assistant auditor of the Ceylon Government Railways.

WE regret to record the death of **Mr. William Platts**, proprietor of George Turton, Platts and Co., Sheffield. He served his apprenticeship with Messrs. Marshall, Sons, and Co., Limited, Gainsborough, and subsequently represented the firm in Australia from 1886-90. He joined Mr. Geo. Turton in 1890, and the works in Saville Street were much extended. Mr. Turton retired in 1894 and Mr. Platts became the sole proprietor. Under his management the business continued to grow until it has become one of the most important spring and buffer making works in the country. The coiled spring department is capable of turning out 100 tons per week. He took out several patents in connection with buffers and springs, the two most important and widely adopted being for the socket plunger buffer and the ribbed section volute springs. He died on the 14th ultimo at his residence in Sheffield at the early age of 46, and his decease is regretted by all who knew him.

Threatened Strike on the North-Eastern R.

THE utter futility of the policy adopted on the N.E.R. of "recognising" the A.S.R.S. is apparently to be demonstrated at an early date, because, as Mr. Bell says, there is just now a mania for strikes on the N.E. coast and the N.E.R. men do not want to be out of it. The men having refused the Board of Trade Conciliation Board's scheme, the best thing the company can do is to see the strike through as a more favourable time than the present could hardly be selected.

*

The Shrewsbury Accident.

COL. YORKE's report upon the fearful accident at Shrewsbury on October 15th, when it will be remembered that a very heavy L. and North Western train from Crewe left the metals at the curve entering Shrewsbury Joint station. The curve is at the foot of a long descent, and the speed on it is limited to 10 miles an hour, whereas the train was travelling at 60 to 65 miles an hour. The report is of great length and fulness, the conclusion arrived at being that the driver and fireman were dozing or sleeping until it was too late to avert the disaster. The report has given offence to engine men, and a meeting held in connection with the Associated Society of Locomotive Engineers and Firemen have already passed a resolution "that the time has arrived when practical men should be appointed to enquire into accidents on our railways." The brakes were, says the report, in good order and of ample power.

*

Amalgamated Society of Railway Servants.

THE 36th annual report of the A.S.R.S. states that the membership numbered at the end of the year 97,561, an increase during the year of 27,431, of whom 25,000 are said to be locomotive men. The income was £102,183, an increase of £19,204. The entrance fees amounted to £2,270, or more than double the amount in the previous year. The expenditure amounted to £67,747—an increase of £16,934. The total

funds amounted to £397,169—an increase of £34,435. These figures show the advantage of an agitation for a strike just as a big fire benefits insurance companies.

*

Conciliation Boards; L. & North Western, Midland, North London R., and Furness Railway.

DURING the past month the results of the elections for the men's representatives on the Conciliation Boards of the L. and North Western, Midland, North London and Furness railways have been announced by the Board of Trade, and in the great majority of cases the candidates run by the Amalgamated Society of Railway Servants have been highly successful.

The L. and North Western R. for the purposes of the Conciliation Boards has been divided in six districts and on each board seven grades (loco, signals, outside goods, passenger, way and works, inside goods and carting) are represented, some by two members and some by one, a total number of 63 seats being ballotted for. The A.S.R.S. "ran" candidates for all the seats and only five were defeated. The voting on the company's offer to pay the expenses was :—Against 17,468, for 10,818, no answer 1,104, spoilt papers 1,120.

The Midland R. has been divided into five districts, and will therefore have five Sectional Boards, on each of which two representatives of each of six grades (loco, signals, goods, passenger, way and works and carting) will sit, or a total of 60. For these seats the A.S.R.S. "ran" 57 candidates, and of these 54 were elected, generally by large majorities, and 3 were defeated.

On the North London R. Board there were only 8 seats (representing four grades) to fill, and of these the A.S.R.S. ran 5 candidates, of whom 3 were elected. A vote was also taken in regard to the offer of the company to pay all the expenses of the Board and arbitration; 590 were in favour of accepting the offer, 301 against, and 90 gave no answer.

For the 12 seats on the Furness R. Board the A.S.R.S. ran 12 candidates, and they were all elected. On the payment of expenses question the voting was 390 against accepting the company's offer, 365 against, and 45 returned no answer.

*

Belgium's New Type of Time-Table.

THE time-table, *Indicateur des Chemins de Fer*, now in use in Belgium, is about to be replaced by a new type of book, which will be introduced before the end of the year. It will be twice as big as the present book, as it will be "bilingual," presumably, French and Flemish. Fortunately the new guide will be arranged in "zones," each of which will comprise a certain number of pages and bound on strips of linen, so that any section or "zone" may be detached easily. There are to be four editions annually, each consisting of 150,000 copies.

*

The Piershill and Portobello Widening, N.B.R.

THE contract for the widening of the North British R. between Piershill Junction and Portobello East Junction has been let to Messrs. Hugh Symington and Sons, Coatbridge, and the work, which is estimated to cost about £76,000, has just been commenced.

*

The Newburgh and North Fife Railway.

THIS line, which has been in the course of construction for some considerable time, is not expected to be ready for opening until late in the year. Messrs. Watson, Edinburgh, have obtained the contract for the station buildings, etc.

*

Valve Gears of Locomotives.

IN our issue for last January we published the Report of the American Railway Master Mechanics Committee upon Valve Gears of Locomotives, and in which the weights of the various parts of the Walschaert and Stephenson gears are given. Our attention was at once drawn to the fact that the items in the second column of the table on p. 15 did not add up to the total given. In reply to our enquiry the secretary of the Association informs us that one of the stationary parts of the Walschaert gear, viz., the "valve motion bearer," weighing 966 lbs., had been inadvertently omitted in the Proceedings. The correct figures are given below :—

	Complete.		Moving Parts Only.	
	Stephenson.	Walschaert.	Stephenson.	Walschaert.
Crossheads	676	746	676	746
Guide bearer	814	1,116	—	—
Guides	1,712	1,712	—	—
Eccentrics	600	—	600	—
Crank arms	—	250	—	250
Eccentric straps ...	1,100	—	1,100	—
Main crank pins ...	520	516	520	516
Links	238	418	238	413
Reverse shaft	325	655	325	655
Rockers and boxes ...	618	730	618	730
Rocker rods & hangers	160	—	160	—
Link bearing	—	234	-	—
Eccentric rods	184	264	184	264
Valve rods	220	546	220	546
Valve yokes	154	140	154	140
Valve rod guide ...	24	28	-	—
Valve motion bearer...	-	966	-	—
Complete set ...	7,354	8,321	4,864	4,265

Lighting Incandescent Gas Burners Simultaneously and Instantly; Eastern Railway of France.

LIGHTING incandescent or ordinary gas lights throughout a train is a simple operation, but it takes time, and can therefore only be conveniently carried out at the carriage sheds or at such stations as the train, for traffic purposes, stops a sufficiently long time. Moreover, especially in this country, the gas lights in carriages are burning for many hours just to light the train while it is passing through a tunnel. With electrically lit carriages this difficulty does not arise, because the lights can be controlled more easily, but with gas, though it is easy to arrange—particularly on corridor trains—for the lights to be turned out it is not easy—we might almost say possible—to arrange for them to be relighted should it be necessary to do so, except by means of bye-passes, which also burn a great deal of gas unnecessarily.

To surmount these drawbacks experiments have been carried out since October, 1903, on the *Ch. de Fer de l'Est* in France, and they are described at length in the *Revue Générale des Chemins de Fer* by MM. M. E. Biard and M. G. Mauclère, of the locomotive department of the Eastern R. of France, and who conducted so much of the early experimental work connected with the introduction and adaptation of vertical incandescent gas mantles for lighting railway carriages, and of which the Company has now 16,000 in use.

The first experiments were made with pastilles of spongy platinum suspended in the chimneys of the lamps a little distance above the mantles, but the method was found not to be relaible on account of the low heating power of oil-gas.

Then electricity was turned to, and the experimental carriage (3 compartment 1st-class) was fitted with an arrangement making sparks across the top of the mantles by a Ruhmkorff coil and 2-cell battery. This method frequently failed owing to the difficulty of conveniently insulating the wires carrying the very high tension current.

Next an arrangement employing spiral platinum wires across the chimney above the mantles and a low-tension current from a 2-cell accumulator and regulating rhéostat was tried, but the platinum wire was delicate and gave trouble and the accumulator gave great trouble and was difficult to manage.

Finally the system here illustrated was adopted, and has given satisfaction. It consists of a sparking plug and a transformer being fitted to each lamp; each group of three lamps in series being connected to a magneto machine; and a trap for rapidly clearing the pipes of air before lighting.

Fig. 1 is a diagram of the arrangement for a bogie carriage with 8 lamps for the compartments, 1 for the lavatory, 1 at each end for the vestibules, and 4 for the corridor. Fig. 2 is a view of the magneto machine which is

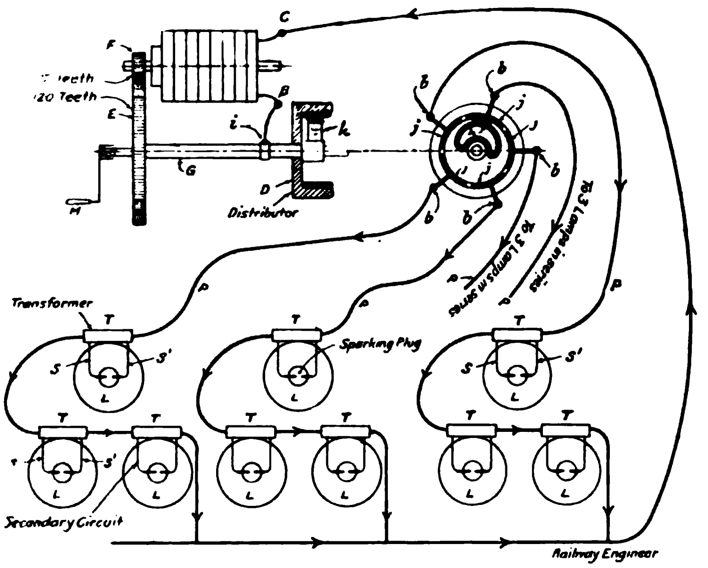


Fig. 1.—Ignition of Incandescent Mantles.

fixed inside the lavatory compartment, a hole being put through the partition to insert the turning handle. The

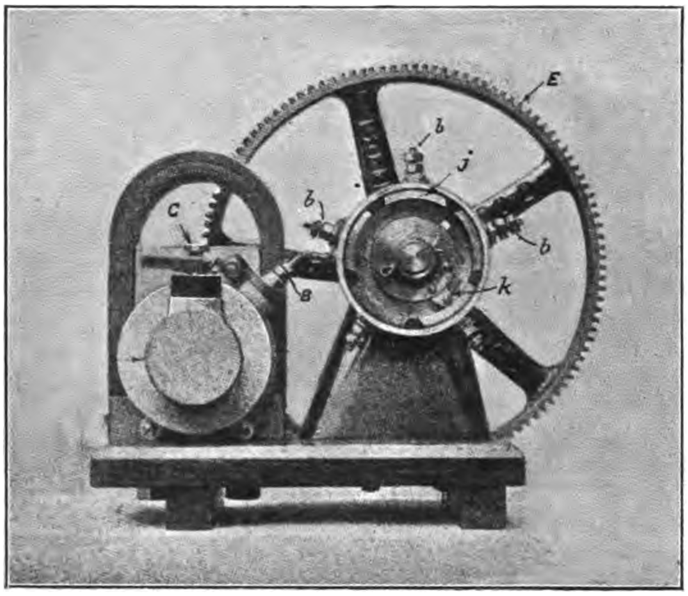


Fig. 2.—Magneto Machine.

magneto machine produces a current of from one to two amperes at 10 to 12 volts. The wheel *E* and the pinion *F* have a ratio of 10 to 1.

Attached to the magneto machine is a distributor *D*, which consists of a fixed ring of fibre carrying the contacts, *j j*, insulated from each other, to which the wires to the groups of lamps, *L*, are attached by terminals, *b b*. To the spindle *G* is attached an arm carrying a contact *k* mounted on a spring; the contact rubs against the contact pieces inside the ring as the handle of the machine is turned. One of the poles *B* of the machine is connected to the spindle *G* by means of a rubbing contact *I*. The return wire from the lamps, *L L*, is connected to the other pole *C* of the machine.

Close to each lamp on the roof is placed vertically a transformer *T*, of which fig. 3 is a section. They consist of a core of laminated soft iron surrounded by a short coil of thick wire and a long coil of very thin wire. The ends of the thick wire coil are connected to the machine and the ends of the thin wire to the ends of the wires in the sparking plugs, which are placed in the lamps above the mantles.

Two patterns of sparking plugs have been used, the vertical, fig. 4, and the horizontal, fig. 5. The plug *A* is made of porcelain and the stout sparking wires, *F* and *G*, figs. 4 and 5, are of nickel pointed with platinum. It is essential that the points of the wires should be truly central and that the lamp should be provided with a bell *C* (of white enamelled iron), because when running the draught is considerable and the gas is too diluted with air. These plugs have been designed to fit existing lamps and not to interfere with the ordinary method of lighting by means of spirit torches.

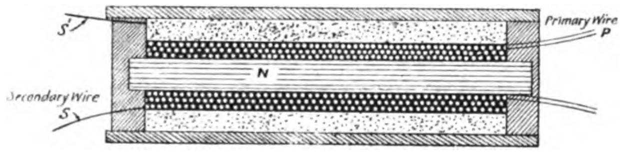
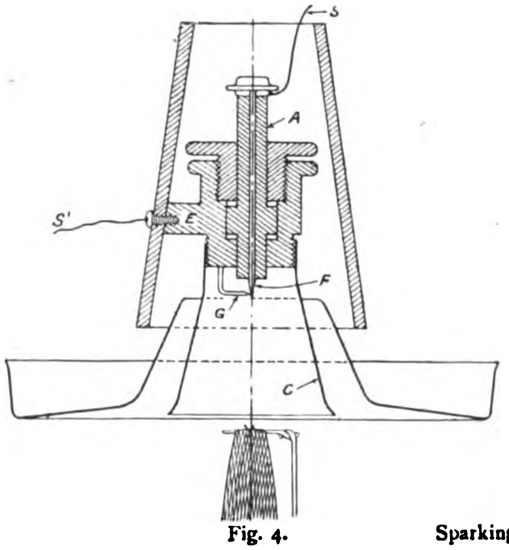


Fig. 3.—Transformers.

The wires, 2 *mm* diam., may be run inside the carriages, but it was found more convenient to use lead covered wire laid outside on the roof.

The gas cock is placed inside the carriage near the handle of the magneto machine and so arranged that both can be worked by the gas-man from the platform without his entering the carriage. Two or three turns of the handle gives 8 to 12 sparks in each lamp, and it has been found that the apparatus is sensitive enough to light all the lamps on the first revolution.

One of the difficulties which attends turning out gas lights is that the pipes gradually fill with air through the minute holes of the injectors of the burners, and it has been found that after the lamps have been out 12 hours that 2½ to 3 minutes are required for the gas to expel the air before relighting. To obviate this inconvenience and to bring the gas nearly on to the level of electricity regards instantaneous lighting the trap illustrated by fig. 6 was designed. It is placed on the roof and connected near to the end of the gas supply pipe.



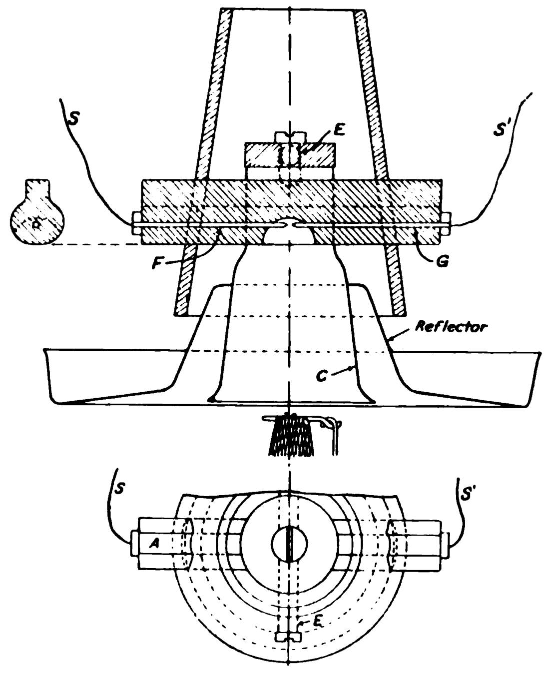


Fig. 4. Sparking Plugs. Fig. 5.

Fig. 6 shows the trap in the state when all the burners are alight. When the lights have been out for some time the float *G* will be at the top of the bell *C* and the level of the oil at *aa*.

When the gas is turned on under a pressure of 200 *mm* (7.87ins.) of water the air under ordinary circumstances must be expelled through the minute holes in the injectors of the burners, but with this trap it at once finds an easy escape through B, fig. 6, into the bell *C*, the float *G* descends, and the level of the oil outside rises to *cc* and inside *C* falls to *bb*, as shown. When the lights are turned down the pressure of the atmosphere through *E* on the oil gradually forces back the air from *C* into the pipes. Should the pressure of the gas be greater than that above mentioned owing to the regulator being out of order the gas cannot escape to the atmosphere, because the float *G* supports by the tube *I* the heavy steel ball H, which will be left on the gun-metal seat *J* when *G* has fallen below a certain level, and thus the entrance to the bell *C* will be closed. The same result would follow the leakage of the oil so that its level fell much below *bb*, and the escape of the gas to the atmosphere would be prevented.

In service this little appliance has worked perfectly. It reduces the time necessary to clear the pipes from 3 minutes to 30 seconds, and prevents the explosions which generally occur with the lighting. The two carriages fitted in November, 1906, and June, 1907, respectively, have given no trouble whatever, and the results obtained are considered to be very encouraging.

The three principal advantages of this system of instantaneous lighting are:—1. Great economy of gas. It is stated that on the express day service Paris-Bâle-Paris alone, on which, owing to several tunnels on the Eastern railway and the Alsace-Lorraine system, the lights must be kept burning 5½ hours, an economy of 223fr. (£13 11s.) per carriage per annum for gas will be realised. 2. The life of the mantles is lengthened from about 70 to 80 days in express service to 100 to 105 days. 3. It renders unnecessary the practice of men passing quickly along the roofs of carriages to light the lamps, which practice is dangerous, especially in frosty weather.

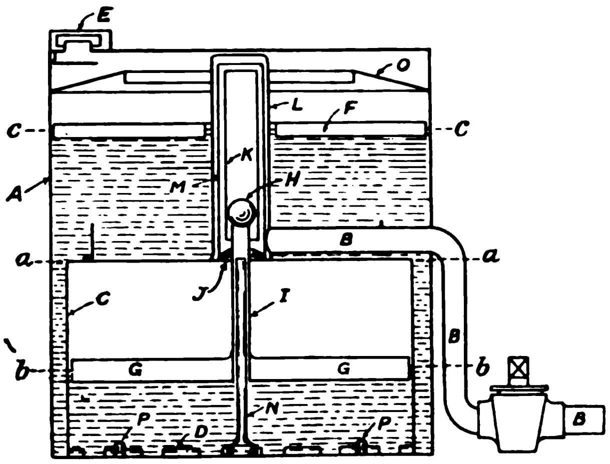


Fig. 6 Section of Air-Escape Trap.

A is a cylindrical vessel of 5 litres (8·8 pints) capacity, containing coal-oil non-congealable and non-inflammable.

B, connection with gas main near the end of the pipes on the carriage.

C, bell fixed to the bottom of *A* with openings *D* permitting the oil to enter from *A*.

E, opening in *A* communicating with the atmosphere.

F, float to prevent the shaking of the oil.

G, float supporting the vertical tube *I* on which the ball-valve *H* normally rests off its seat *J*.

K is a tube to guide the ball-valve *H*.

L and *M*, concentric tubes making an annular passage for the gas to enter the bell *C* and forcing the gas to mount to the top of the case so as to prevent the possibility of the oil entering the pipes through *B*.

N, guide for the float *G*.

O, collar to oppose the throwing of the oil.

P P, stops for the floats *F* and *G*.

On the Eastern R. of France the suburban trains are "doubled decked," and it appears that it takes 2 gas-men 25 minutes to completely light the lamps in a train of 16 vehicles, of which 12 are "double decked" and have 8 lamps for the inside and 4 for the outside. With the system above described one man would light the train in 10 minutes or two men in 5 minutes.

The agents in this country for the burner used on the Eastern R. of France and also for the ignition apparatus described above are The London Lamp Works, 2, Dyer's Buildings, Holborn, E.C.

Johnson's "All Electric" Point and Signal Apparatus.

The salient feature of this apparatus, which was designed by Mr. A. H. Johnson, signal and telegraph engineer, L. and South Western R., is the points-motor mechanism illustrated by figs. 1 and 2.

A double ended ram *a* carrying the roller *b* operates the points through the medium of the escapement crank *c*. The ram chambers and duct *d*, and also the bye-pass *e*, are filled with a light mineral oil. The chamber *f* contains two small gear wheels about 1in. diam., one of which is driven by the electric motor *m*. The radial gate-valve *h* normally closes the bye-pass, and is held as shown, by the armature of coils *n*, which receives current simultaneously with motor *m*. When the motor *m* is operated and the wheels *f* thereby revolved, the ram *a* is traversed, thus moving the crank *c* and the points. The rod *k* is connected to a lug on the end of the roller pin, and moves the facing-point lock and usual locking-bar.

Now should a train be standing on the bar, or the points be obstructed when current is applied to the motor *m*, the ram *a* is thereby stopped, but the small ram *t* flies up against its spring, and raises armature *n*, thus breaking the circuit of the holding magnet coils. The bye-pass valve *h* is then free to turn, and the motor *m* freely circulates oil through bye-pass *e*. It may be noted that the motor has been run thus for three hours without any detriment, the current at 100 volts being about 1 amp.

The time taken to move over the points and point lock is 2½ seconds and the average current about 2 to 3 amps., according to the fit of the points. The ram, together with the escapement crank, form an effective point and lock movement.

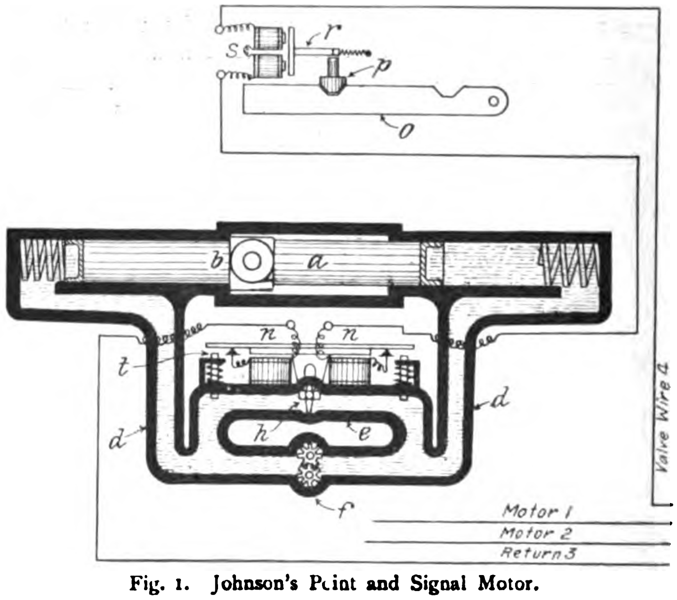


Fig. 1. Johnson's Point and Signal Motor.

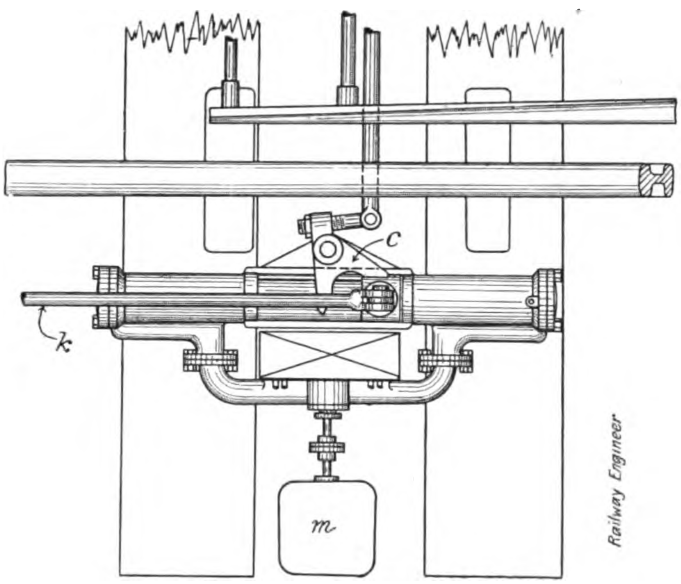


Fig. 2. Johnson's "All-Electric" Point-working Mechanism.

In another form of the point motor a hinged valve is substituted for the ram.

The reduction gear consists merely of two ordinary gear wheels, and all working parts outside the motor itself run in oil, including the coils *n*.

An ordinary duplex point lock *o* is adapted to be normally locked by the dog *p* and the armature *r*. Coil *s*, which releases this lock, receives current at the same time as coils *n*.

Fig. 3 shows the operating lever with operating and check lock circuits, but the mechanism is also applicable to a "constant-detector" circuit.

To reverse the position of the points worked by motor *m*, the signalman pulls over the lever until shoulder i^2 of slide *s* is stopped by the check lock i^1. The battery *b* then works the motor *m* via circuit *b*, d^2, 11, 14, *b*, *o*, o^1, *y*, m^1, *m*, k^1. The valve *v* is held closed by its coils via circuit *b*, d^2, 11, 14, b^1, b^2, *t*, v^1, *k*, *v*, k^1. The switch points are thereby reversed, and the bye-pass valve *v* is forced open, thus holding the valve circuit open at *z* z^1. But the valve wire v^1 now has another route via "make-and-break" wheel *g* and x^1 y^1; and as armature of y^1 is held over by coil *y* then y^2, and switch points being reversed then 7, p^2, 9, k^1.

The battery current in valve wire v^1 is now caused to pulsate by the action of the "make-and-break" *g*, which is driven by motor *m*, and as the pulsations pass through the primary *t* of transformer *t* t^1, a current is set up in the secondary circuit t^1, e^1, *e*, e^2, *r*. This operates the miniature motor *r*, and holds away the brake 38 by the coil r^2. The motor *r* raises the lower spring of circuit maker r^1, which closes the circuit of battery j^1, thus lifting check lock i^1 by coil and armature *i*. The signalman, on hearing the slight rattle made by the motor device *r* r^2, knows that the check lock is released, and he then completes the backward stroke of slide *s*, thus cutting off battery *b* from the operating wires and so bringing motor *m* to rest. Motor *r* stops by the action of brake 38, and the circuit of battery j^1 is severed at r^1 by stoppage of motor *r*.

The brake 38 also prevents the operation of motor *r* by an accidental pulsation, or a series of slow pulsations.

Attention is drawn to the means employed for safeguarding the points against unintentional operation by a stray current caused by accidental contact.

It will be noted that valve *v* is controlled by a separate wire, which in railway signal parlance may be said to "slot" the points.

An accidental contact between a live wire and the motor wire *o* or *h* would only cause an idle movement of the motor. Both the motor and valve wires would have to be simultaneously fouled to cause trouble, and even then the points would not be operated should a signal for the route set be cleared as lock *k*, fig. 3, or *r* in fig. 1, is held locked by a coil in connection with the signal circuit.

Still another safeguard is adopted by the usual expedient

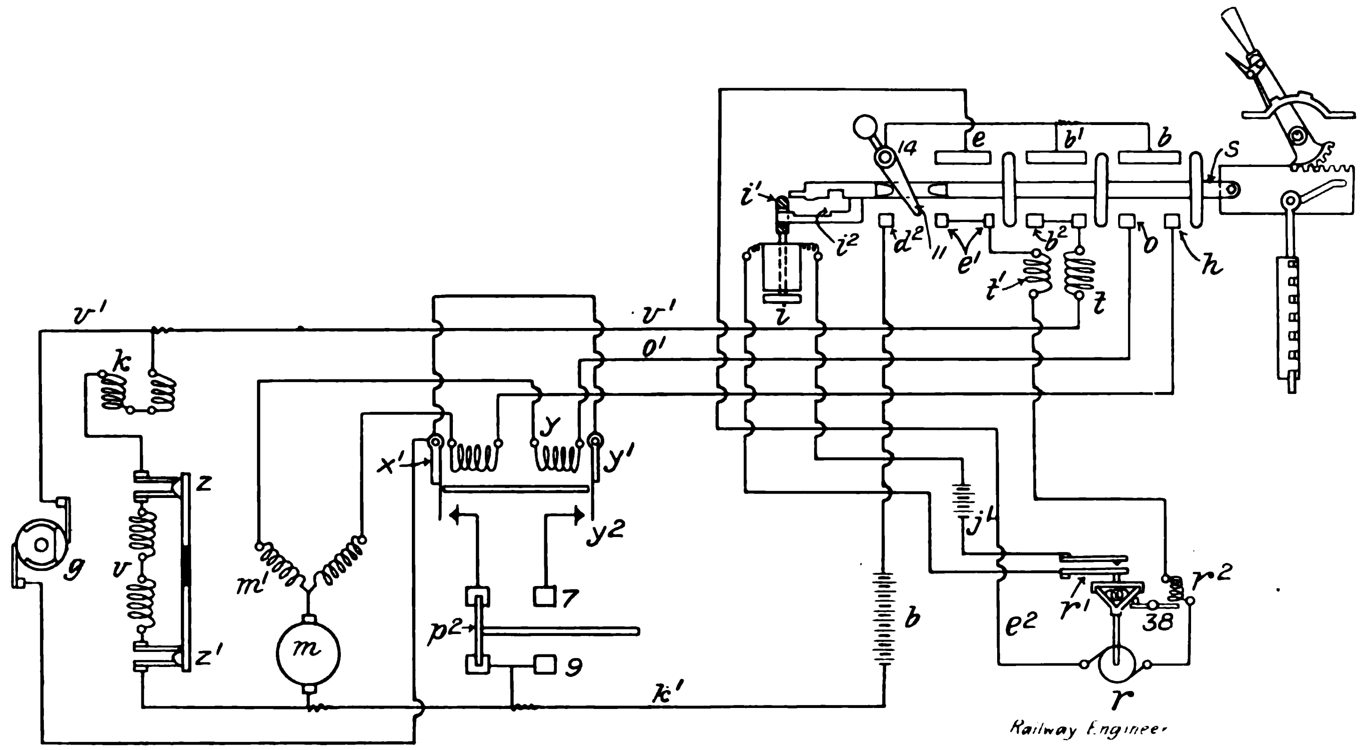


Fig. 3. Johnson's "All-Electric" Point and Signal Working Apparatus.

of earthing the operating wire at the lever in either of its completely thrown positions. This feature is not shown.

The apparatus is manufactured by McKenzie and Holland and Westinghouse, Ltd., who are fixing the system at Praed Street Junction and Aldgate on the Metropolitan R. in connection with the provision of power and automatic signalling on that line between Aldgate and Praed Street and Bishop's Road.

"Constant-detection" circuits are to be employed. These allow the point levers to be pulled fully over or fully put back at one movement, but no signals can be pulled over unless and until the points it governs are in position and any movement of a point when a signal it covers is "off" causes the signal to go to danger.

Signals are also operated by the same method.

Rapid-Acting Vacuum Brakes.

The introduction of "Rapid-acting Valves" or "Accelerators" constitutes one of the most important improvements in the mechanism of the vacuum system of continuous brakes, because the speed, or in other words the minimum of time in which the continuous brake can be applied, either partially or fully, throughout a train of any length, is dependent on the rapidity by which the reduction of the vacuum, *i.e.*, the increase in the pressure, in the main conduit pipe can be conveyed from the driver's valve on the locomotive to the last vehicle.

In considering this question it must be borne in mind that the most important feature in the first instance is not the violence of the braking of the wheels but the rapidity by which the braking can be distributed serially, or synchronised throughout the train, and at the same time, amongst other things, avoid complete braking at the front of a train before that at the rear has had time to take effect, which would produce buffing strains, and in goods trains buffer concussions, with a "bunching up" of the vehicles, resulting in damage to rolling stock as well as other dangerous effects, to say nothing of discomfort to passengers, etc.

"Accelerators" have been designed to meet this object, but they have been made so as to come into operation on emergency applications only, whereas the more usual requirement of an ordinary service application has been overlooked. One of the results of this has been that enginemen, when applying the brake under ordinary circumstances, have been rather afraid of making a slip, and thereby bringing the emergency valve into operation, and thus a tendency to leak the brake into action, resulting in actually retarding its application, has arisen.

Special accelerators have now been introduced to overcome these difficulties, and by fitting them to each vehicle of a train a quick application of the brake is secured both in emergency and ordinary service applications. They are so designed that when the driver opens his valve for a service application, which reduces the vacuum in the train pipe by a certain amount the valve in the accelerator on the first vehicle automatically opens a communication to the atmosphere, which admits a certain amount of atmospheric pressure, and this additional reduction of vacuum is sufficient to quickly communicate the same effect to the succeeding vehicle, and so on seriatim; each accelerator in succession comes into action automatically throughout the train and causes a very rapid transmission of change of pressure along the main conduit. These valves are so constructed, however, that they only remain open just sufficiently long as to allow the required reduction of vacuum to be passed on to the next valve in succession, when each in turn automatically opens, closing again after having admitted just sufficient atmospheric pressure to partially apply the brakes with rapidity and regularity throughout.

If any further or increased brake power be required a further reduction of vacuum by the driver again brings these accelerators into action, and this may be repeated until the vacuum in the main conduit is nearly destroyed. As these particular valves open and close in a definite period of time they would not exert sufficient influence, in the case of an emergency application, to fully apply the brakes, and they are therefore augmented by a more powerful auxiliary valve, which only opens on a sudden and large reduction of vacuum, produced by a sudden emergency application of the driver's valve, and remain open during a sufficiently long period to meet the necessary requirements

The enormous influence which such accelerators exert has been demonstrated by actual tests, and the following results show the remarkable gain accomplished.

On a train of 60 vehicles, equal to about 1,800ft. in length, it was found that the time required to fully apply the brakes when making an emergency application was 50 seconds without accelerators and only 5½ seconds with accelerators. The distance covered in these times at 40 miles an hour would be 2,933ft. and 322ft. respectively, the speed of the air in the pipes being 35ft. and 327ft.

For an ordinary service application the time required to apply the brakes was 30 seconds without accelerators and 3 seconds with them. In these times the distance covered by a train travelling at 40 miles per hour would be 1,760ft. and 176ft., and the speed of the air in the pipes 60 and 600ft. respectively per second.

The following figures show the comparative length of time with and without accelerators that it takes for change of pressure to take effect on the 30th and 60th vehicles after an emergency application of the driver's valve:—Without accelerators, 6·5 seconds and 14 seconds; with accelerators, 1·75 seconds and 2 seconds.

The above figures show how rapidly the change of pressure is transmitted throughout the train, and how quickly and certainly the brake blocks are almost simultaneously applied, with the requisite degree of pressure, for the various conditions of braking.

The fitting of these accelerators on odd, or a few vehicles in a train only, causes neither trouble nor objectionable results in working, so that they can be fitted gradually to the rolling stock of a railway.

It must be admitted that the results accomplished are remarkable, and the serious and careful notice of the railway officials cannot fail to be drawn to them, particularly as at a small cost, and with little trouble, not only is the efficiency of the brake and control of high speed and long trains enormously increased, but the risk attending the working of railways will be reduced, and consequently accidents and destruction to rolling stock, while the lives of the railway staff and passengers are better safeguarded.

E. S. Luard.

Erection of Bridges.—X.*

H.—Miscellaneous *(continued).*

River Dal Railway Bridge in Sweden.

This bridge is situate about 10 miles from Fahlin, and carries the main line between Gefle and Gothenburg.

The central span is 208ft. clear and the two side spans are 80ft. each, the height above water being 40ft. (fig. 30).

Large quantities of floating timber and rafts are constantly travelling down the river in the summer season so that it was impracticable to adopt any kind of intermediate prop or staging in the central span, but the two side spans were erected on scaffolding in the usual way.

The rolling out system was at first intended for the erection of the central large opening, but it was found that the protrusion of a span so large as 208ft. with only one 80ft. span to balance the protruding portion was not feasible.

A staging suported by chains was next suggested as a temporary scaffolding upon which the bridge could be erected, but it was discovered that this was out of practicability in that virtually a suspension bridge would have had to be erected almost as strong as the permanent structure itself.

Timber being plentiful in the neighbourhood, it was next thought that a projecting timber staging resting on each side of the river could be provided, but when worked out in detail this, too, was condemned as unsuitable.

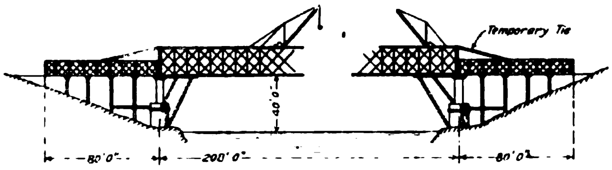


Fig. 30.—River Dal Railway Bridge, Sweden.

The plan of erection ultimately adopted was as follows:—Four strong ties were fixed sloping down from the end post of the large girder on to about the centre of the smaller girder. The ties used were of such a section that they could be worked in the permanent work, and economy was ensured.

The bottom boom of the short girder was strengthened to resist compression by the fixing of struts, also intended for use in the permanent structure.

The shorter girder was then weighted down, a load of 93 tons, chiefly rails, being used for the purpose. This load was distributed at the ends of the girders and at intermediate points in such a manner that the girder was not in any point overstrained.

This weighting being arranged and fixed, the two halves of the central span were built out one from each abutment, simultaneously. Each member was fixed just as it left the maker's works, and riveted in position.

As the central span girders were built out in this way the cross girders and railbearers were added to give the required stiffness, but the main flange plates were left off until later, it being considered that they would serve no other purpose than to add useless weight to the overhangs.

The maximum weight lifted and fixed at one time was 25 cwts., and long jibbed Scotch derricks were used for the handling of the material, they being found more suitable than ordinary portable cranes, which were used at first but subsequently abandoned.

When the two halves of the span met in the centre it was found that although the alignment was true, yet the ironwork did not meet within one inch. This was, however, discovered when the temperature was low, and during the next day, when the sun was shining brightly, the gap disappeared and the closing up was done.

When the temporary ties were cut away it was found that there was only a very slight deflection at the centre of the span.

Five months were occupied in the work, but at the time chosen the weather was very cold and inclement, and the days short.

The Paderno Viaduct, Italy.

The Paderno Viaduct carries a single track line of the Meridionali Railway Company across the valley of the Adda, near Milan, and was built in 1889.

It has a total length of 871ft. 2ins., and is divided into eight deck spans of 108ft. $10\frac{3}{4}$ins. carried on three towers or piers, two arch towers, and three points of contact with the arch.

The arch has a span of 492ft. between centres of the abutments, the rise from the chord to centre of crown being 129ft. 4ins. From water level to rails the height is 242ft. 6ins.

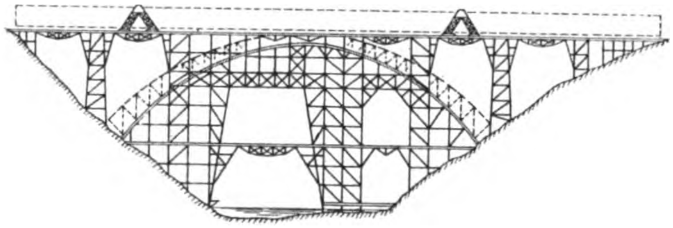


Fig. 31.—Paderno Viaduct.

Fig. 31 shows the timber centre and trestling. Three rail services were provided, one near the water level, a second at the lower chord of the arch, and a third at the deck level. At the deck level a double line of rails were provided, and these carried two sixteen-wheeled derricks which were used for the hoisting and transport of the bridge members.

Transverse girders were built between the legs of the derricks and these carried rails upon which four wheeled crabs were placed, and upon the top of the derricks were fixed rails for a jib crane. The maximum weight for each derrick was 15 tons.

Central Bahia Railway Bridge.

This bridge is situated in South America, and is of the lattice girder class. It is placed over a precipitous gorge 180ft. deep, and the use of scaffolding of the usual character was out of the question. Another reason prohibiting the use of scaffolding was that timber was expensive, as also was skilled labour, and it was necessary to handle the work in the field so as to require as small expense as possible.

The span is 203ft., and as the bridge is for a single line two main girders only were required with the usual cross girders and floor, the total weight of the bridge being nearly 120 tons.

The manner of erection (see fig. 32) was most unique and very different from anything that we have previously described. The basis of the erecting arrangement was a pair of steel wire ropes $1\frac{5}{8}$ins. diameter, slung in suspension

*The previous articles of this series appeared in the *Railway Engineer* of the following dates:—I., December, 1905; II., November, 1906; III., April, 1907; IV., June, 1907; V., August, 1907; VI., October, 1907; VII., November, 1907; VIII., January, 1908; IX., March, 1908.

bridge manner over two wooden trestles at each end of the bridge, provided with rollers, over which the wire ropes were slung and made tight to winches at each end of the rope. These suspension ropes were guyed from the middle of the openings towards each abutment by four $\frac{5}{8}$ins. steel wire ropes, which assisted both in the steadying and alignment of the wire ropes, and also in the controlling of the travel of the half girders.

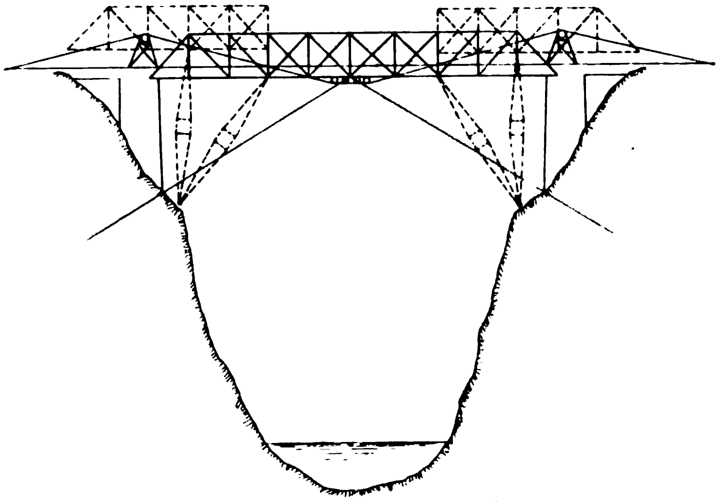


Fig. 32.—Central Bahia Railway Bridge.

Two rocking booms, of braced wooden construction, 80ft. long, were also provided at each abutment, being hinged at the lower end so that they could move forward towards the centre of the opening as might be required.

Upon the main wire ropes roller bearing shoes were provided to run along on the top of the ropes, these shoes being intended to receive the ends of the girders in mid span and assist the rocking booms to support the load.

Each girder was made in two halves, the joint being made in the centre of the opening, and when each half of the girder had been built on the top of the abutment it was hauled forward by a $\frac{3}{4}$ins. steel wire hauling rope attached to a locomotive on the opposite bank. The rocking bar was of course raised to its highest level, and the second panel point of the half girder hauled over and made fast to it.

The abutment end of the half truss at this stage rested on skids working along the rails, the shore end of the half truss being counterbalanced so far as this could be arranged.

When the second panel point of each half girder was thus suspended upon the wire suspension rope assisted by the 80ft. boom it was hauled forward towards the other half girder of the bridge, the two halves thus meeting in the centre of the opening, and the connection was then made good by riveting.

Of course, the level of the girder became lower as the launching out was effected since it necessarily followed the projecting end of the erecting boom, the top of which moved like the spoke of a wheel around its bottom pivot on the rock abutment.

The closing ends of the half girders at the centre of the span were adjusted by means of jacks and cam-jaw levers bolted to the chords of the girderwork, which held them up during the riveting. This done, the cross girders and floor system were added and the work completed.

The Pwll-y-Pant Viaduct.

This viaduct is on the Brecon and Merthyr extension of the Barry Railway, and was opened for traffic so recently as 1905 (see fig. 33).

It is about 100ft. in height, and consists of eleven spans of steel lattice girders each 171ft. in length and 17ft. deep. The weight of steelwork in each span amounts to 275½ tons, each girder weighing 88 tons.

The girders were erected in the telescopic fashion, being put together at one end of the viaduct on ordinary timber where the ground was higher, no height of the staging being greater than 60ft. The staging was built for a length of two

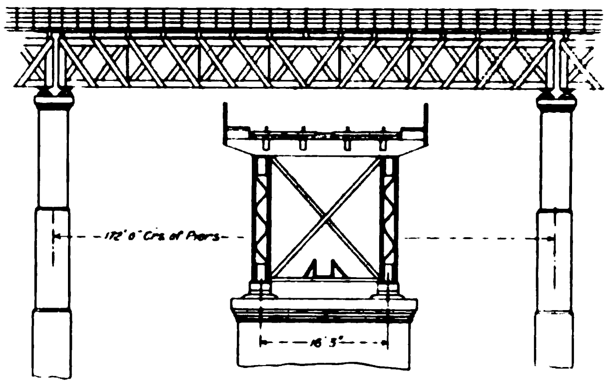


Fig. 33.—Pwll-y-Pant Viaduct.

spans of the viaduct, and a ten ton travelling crane worked along the top of the staging to assemble the various parts of the girders, and also for the lifting up to the top of the staging of the parts of the girders, which were conveyed to the side of the stage on ordinary railway sidings at ground level.

The booms of the girders were each delivered to the site in five lengths, and all the field rivets were inserted by pneumatic riveters.

The main girders were to be spaced when resting in their final position on the piers at 16ft. 3ins. centres, and upon these were placed cross girders 27ft. in length, projecting over the main girders at each side to form footpaths 3ft. wide.

All the web members of the girders, both struts and ties, were specially designed so that they would be able to resist the temporary stresses that would come on them during the launching out process.

Two of the main girders, in fact those intended for permanent use in No. 1 span (which was the furthest away from the temporary staging) were used as launching girders and were each provided with temporary nose-pieces 30ft. 4½ins. in length, which were riveted on the front ends of the two girders, and, of course, were pushed forward in front of them.

Whilst the girders were being erected the launching out girders were placed at 9ft. 9ins. centres, and were therefore inside the space between the two girders already in position at 16ft. 3ins. centres.

After the girders had been put together on the top of the staging they were lifted up from the floor by means of a hydraulic travelling crane mounted on bogie wheels, which ran along roller paths prepared on the upper surface of the top boom of the girders.

The bogie wheels of the travelling crane were made with a sideways movement so that they could work either on roller paths 16ft. 3ins. or 9ft. 9ins. centres, the hydraulic ram being 16ins. diameter, had a range of 11ins. and a lifting power of 180 tons.

When two of the launching out girders were ready for moving forwards they were placed at 9ft. 9ins. centres with the front of the projecting nose overhanging the pier 91ft. 10ins. (see fig. 34), a transverse box girder being provided at their tail ends, holding underneath the girders previously placed at 16ft. 3ins. centres, and were also counterbalanced to prevent them from tipping up at the rear end.

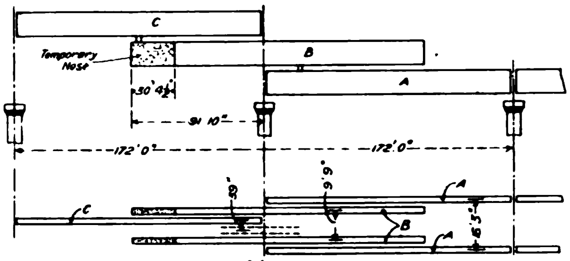


Fig. 34.

Each girder when it was launched was suspended at its centre by the hydraulic crane, which rested at this stage on the two girders placed at 16ft. 3ins, centres.

The diagram (fig. 34) shows how the telescoping movement of the various girders was carried out. Of course all the girders were practically at one level during the whole of the operations, so that the diagram is calculated to mislead unless this is borne in mind.

First, the two girders A were placed at 16ft. 3ins. centres, which was their permanent distance apart. This done, the two launching-out girders B were placed at 9ft. 9ins. centres, and with their nose-pieces or front extensions riveted on were then hauled out by two wire ropes until they reached the position shown in fig. 34. The hauling-out was performed by means of two winches fixed at the bottom of the pier, the wire ropes being conveyed up the face of the pier in front of the launching.

It will be noted that although the centre of girders B is 24ft. 2ins. within the pier, yet this centre does not represent the centre of gravity of girder B with the nose-piece added; and it can be seen at once that the centre of gravity of the B girder with extension will not be far short of the extremity of girder A, on which in fact it rested.

Two of the girders B being thus launched, another girder C was brought up at a distance of 3ft. 3ins. within girder B, and again suspended from its centre was hauled forward until it reached the position shown in fig. 34, where it now rested on two piers, one at each end. The purpose of the nose or extension of girder B will now be clearly seen from the diagram.

The two forward girders being now placed in their position on the front span, but at 3ft. 3ins. centres, the launching-out girder B was run back out of the way, and at once the two front girders were skidded over sideways until they too reached the required permanent distance apart of 16ft. 3ins. centres.

This done, the launching-out girders B were run forward again, but one span in advance of the previous position, and the same operation was repeated.

In the last span, of course, this could not be done, as the two launching-out girders were required as permanent girders for that span. In this case, therefore, a stage was erected, as in the case of spans Nos. 10 and 11, and after the two girders B had been pushed forward as far as possible the nose was cut off and the weight was put upon the staging and the girders were then hauled forward and skidded over to the right distance apart.

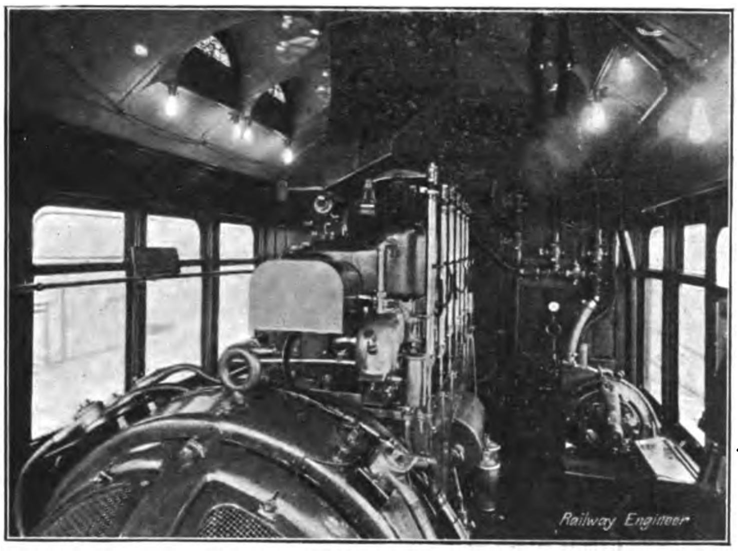
The total weight of the steelwork thus erected was 3,377 tons, and the cost was £19 16*s*. 7*d*. per ton, which included the cost of erection.

(To be continued.)

Strang Gas-Electric Rail Motor Car.

An interesting railway car has recently been completed at the works of the J. G. Brill Company for the Strang Gas-Electric Car Company, with the object of making trips over all the main steam lines east of the Mississippi River, stopping at the principal cities for parties of railway experts, who will watch its operation with a view to equipping branch lines and feeder systems with cars of this kind.

The Strang system consists of a gas engine with a direct connected generator, electric transmission and control, direct electrical connection between the generator and truck motors, and a storage battery. The operation of the car is practically the same as an interurban trolley car. The generator and engine have a capacity sufficient for normal requirements, the generator furnishing all the current necessary; but when starting or when ascending a grade the current necessary would demand an engine and generator of much

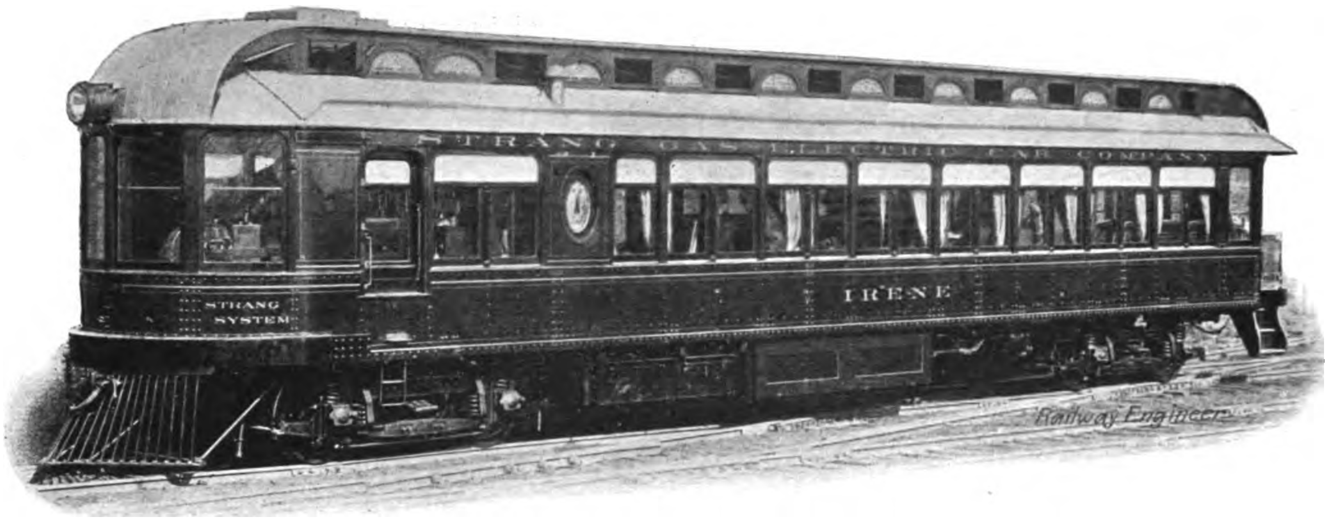


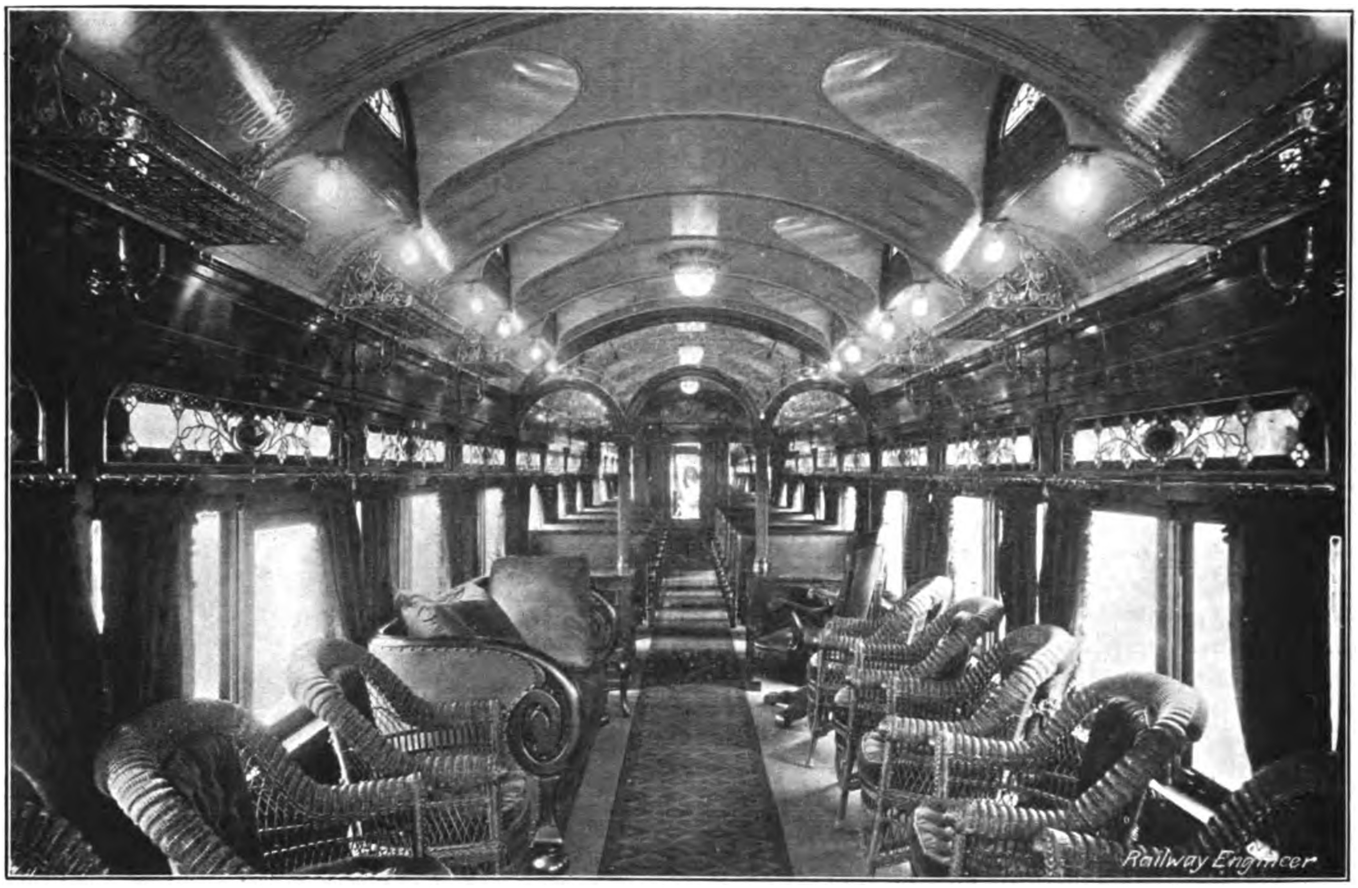
Strang Gas-Electric Rail Motor Car.

larger capacity were it not for the storage battery. The storage battery therefore takes care of what is called the "peak" of the load, or that which is in excess of normal requirements. The storage battery is charged while the car is coasting down grades, coming to a stop or standing still; the engine running until automatically stopped, when the batteries are fully charged.

The battery is placed underneath the car, and the engine-room only needs to be large enough for the engine and the generator. The engine has its six cylinders in line to make it as narrow as possible and leaves ample room for persons to enter the compartment and inspect the operation of the system.

The system of control is that the "multiple unit control" which enables the car to furnish current to other cars equipped with motors to which it may be coupled. The engine, generator, motors, and practically all the machinery





Strang Gas-Electric Rail Motor Car.

have been especially devised and are stated to be important was designed and manufactured by the Strang Gas-Electric Car Co. Many of the devices which control the machinery improvements, *e.g.*, the automatic control of engines by the condition of the battery; roof arrangement for water system of heat radiation; high tension ignition system, etc. The car carries sufficient gasoline to carry it 200 miles and consumes about 0·6 gallon per mile. The engine coaling system consists of radiators placed on the roof of the car and a water circulation by a motor-driven turbine pump. The passenger compartments are heated by pipes connected with the water system.

The car seats 75 passengers and will maintain a speed of 55 miles an hour. It can be made the motor car of a train, being capable of hauling three trailers carrying 75 passengers each. In the event of mishap, its double system of power allows its batteries to drive it for 15 miles.

The car is built of steel with the exception of the interior, which is composed of vermilion wood, richly carved and inlaid. Behind the engine-room is a compartment furnished with transversely placed seats upholstered in red leather, and the rear compartment has comfortable wicker chairs and the usual fittings of a Pullman club car. The observation platform at the rear is enclosed with handsome brass railings. Instead of the usual form of dome, the roof is of a complete arched type, prevented from being mono-

tonous to the eye by ventilator sashes set in at regular intervals and allowing a soft light to come from above through the stained glass with which they are furnished. The ornamentation of the ceiling is Oriental in character and lends the effect of height by ribbons of gold of irregular length reaching towards the centre. Pullman stained windows with stained glass in the upper part also add to the soft diffusion of light through the car, while the large plate glass sashes reach down to within two feet of the floor, adding much to the attractiveness of the interior by the unobstructed view which they afford.

The car is 66ft. long over all and weighs, complete, 114,000 lbs. The engine is of vertical 4-cycle type, having six cylinders, 10½ by 9; 150 h.p. at 425 R.P.M. (continuous rating). The generator is of 85 k.w., 250 volt, d.c., shunt interpole. Motors (two) of 100 h.p.; 250 volt, series wound interpole. Battery of 112 cells; Planté type of 300 amperes hours capacity. Type "M" control; automatic air brakes. The cooling and heating system consists of an electrically-driven centrifugal pump, circulating jacket water through radiators on roof or through heating pipes in passenger compartment. The trucks are the Brill standard No. 27-E3. The car body was designed by Mr. W. B. Strang and Mr. L. G. Nilson, of the Strang Gas-Electric Car Company, and built under their personal supervision.

King Edward VII. Bridge, Newcastle-on-Tyne.*

THE authors describe the construction of this new high-level bridge at Newcastle-upon-Tyne. For nearly 60 years the whole of the North-Eastern R. traffic between north and south passed over three lines upon the old high-level bridge; and in 1899 Parliamentary powers were obtained to construct an entirely new bridge to carry four lines and so located that trains should pass through Newcastle without a change of engines.

The bridge was designed by Mr. Charles Harrison, D.Sc., engineer to the Northern Division of the North-Eastern R. The contractors were the Cleveland Bridge and Engineering Co., Ltd., Darlington.

Foundations.—Electric power was generated at the contractor's yard for working the air-compressors for the caissons, and for driving the whole of the machinery and lighting-plant upon the works. There were three caissons, each 113 ft. by 35ft., and sunk to about 70ft. below high water of ordinary spring-tides. Each caisson was divided into permanent and temporary lengths, the latter being attached to the permanent length at river-bed level. It was carried to a height of about 5ft. above high-water level. The working-chamber of each caisson was domed, and 9ft. 6in. high at the highest point. It was divided into three parts by means of two girders with wide bottom flanges, 3ft. 6in. above the cutting edge. These girders were designed to prevent the caissons from sinking too rapidly in soft ground. Holes were made through their webs to enable workmen to have free access to all parts of the working-chamber. There were three shafts to each chamber, which were pear-shaped in plan, and so designed that workmen could descend the ladders without fear of fouling the skips. Each shaft was served by an electric derrick-crane, and the skips were loaded, passed through the air-locks, and tipped into the hoppers without unslinging or re-handling. The air-locks were designed by Mr. F. W. Davis, with the object of removing the excavated material more quickly than is possible with the ordinary type of lock. The caissons were built immediately above their final resting-place, and were lowered by means of lowering-chains and hydraulic jacks. As soon as the caisson had been lowered sufficiently to float, concreting was commenced, and continued as rapidly as possible by day and by night until the caisson rested securely on the bed of the river.

Several cases of caisson-illness occurred, but only in one or two cases were the results serious. All men employed under compressed air were medically examined before being allowed to work. The period adopted for compression and re-compression was 1 minute for every 5lbs. of pressure, and this was found to be quite satisfactory. Special attention was paid to the proper ventilation of the working-chambers, and 22 cubic feet of free air per minute for each man were supplied. During the sinking of the first two caissons it was thought that the amount of CO_2 in the compressed air was related to the number of cases of compressed-air illness. In the last caisson, therefore, the air was analysed daily, and it was found that the number of cases of illness had no relation whatever to the quantity of CO_2. This result is plotted on a diagram which accompanies the paper. Upon several occasions observations were taken of skin-friction, which was found to range from 5 cwt. to 6·65 cwt. per square foot of embedded surface.

The North Approach.—The approach upon the north side is by means of a 10-chain curve. The railway is carried over the existing Forth Banks warehouse by six spans of steel-work; and after passing through the warehouse, Pottery Lane is crossed at a height of 35ft. above the road. Between Pottery Lane and the north bank of the river are ten semi-circular stone arches of 25ft. span, terminating in an abutment which forms the north abutment of the main bridge.

The Superstructure, and its Erection.—The bridge consists of two spans of 300ft. each, with a land span on the north side of 231ft., and a land span on the south side with an average opening of 195ft. There are three granite piers in the river, 25ft. wide, and the clear headway to the under-side of the girders is 83ft. 6in. from high water of ordinary springtides. The piers have curved cut-waters at each end, and are lightened by voids. There are five girders to each span, of lattice design and 27ft. high, and they are placed 11ft. apart between centres.

The track is carried on longitudinal timbers, resting on floor-plates supported by cross girders attached to the top boom of each main girder. The girders were erected upon timber staging, which was constructed wide enough to build two girders at one time.

The Act of Parliament provided that one of the two waterways should always be kept open during erection. The closing of one channel involved a certain amount of risk to shipping, and in consequence the work was expedited as much as possible. The south river-channel was closed on the 10th April, 1905, and re-opened upon the 29th October, 1905, after the building and removal of staging, and erection of five main girders, weighing 1,636 tons. The north river-channel was closed on the 29th October, and re-opened on the 26th May, 1906.

Experiments were made with sand-blast apparatus for cleaning the steelwork, but the cost was found to work out at 2·16*d*. per sq. ft., or three times the cost of hand labour. There were difficulties in working on a large scale which prevented the system from being used for more than experimental work.

The fan-shaped steel span upon the south side was not contemplated when the work was commenced, but the nature of the foundations upon the south side proved unsatisfactory for arches, and Mr. Harrison therefore decided to alter these to girders. The abutment of this span also forms the wings and abutments for the arches of the south-west and south-east approach curves.

The South Approaches.—During the excavation for the south abutment of the Pipewellgate span, old pit-workings were met with. These were explored, and found to extend under the whole of the foundations upon the south-west and south-east approaches. The workings were therefore cleaned

*Abstract of a paper by F. W. Davis and C. R. S. Kirkpatrick, read before the Inst.C.E.

out, and filled up with brickwork in cement. The arches upon the south-east and south-west approach curves were of ashlar in cement, the abutments and spandrel-walls being of masonry in mortar faced with snecked rubble.

The Cableway.—To expedite construction a cableway was erected, to carry 10 tons with a clear span of 1,520ft. The saddles of each tower were 200ft. above high water, and the dip of the rope was about 65ft. The towers were of steel framework hinged at the foot, and provision was made at each anchorage for tightening or slackening the main rope. The driving-winch was about 35 yards west of the tower upon the Gateshead side, and was of 100 h.p.

The main rope was $3\frac{1}{8}$ in. diam., and weighed over 10 tons. Erection was a very difficult matter, owing to the river-traffic, railway-lines, and roadways below, but was successfully accomplished by drawing the main rope over a lighter rope previously secured to the towers. The cableway proved a success in every way, and not only saved considerable expense in carrying out the work, but materially reduced the period of construction. In particular it was proved to be of special advantage for building and taking down the staging for the girders. All signalling was done by means of flags.

Board of Trade Inspection and Opening.—The bridge was tested by the Board of Trade with a live load of ten locomotives. The maximum deflection in the two river spans was 1/1848th of the span.

The formal opening by His Majesty King Edward VII. took place on 10th July, 1906, and passenger traffic was commenced on 1st October, 1906.

Mr. A. Cameron, Assoc.M.Inst.C.E., acted as resident engineer for the railway company, whilst the authors supervised the work on behalf of the contractors.

Locomotive Journals and Bearings.—III.*

Great Northern Railway.

THE train services of the Great Northern R. have always been noted for their speed, but in recent years the engines which Mr. H. A. Ivatt, M.Inst.C.E., has designed have not only had to increase the speed of the trains, but the East Coast and other trains have increased enormously in weight.

The details illustrated are those of the engines of the "990" and "251" classes, of which the cylinders (outside) are 19in. ($18\frac{3}{4}$ when new) by 24in.; the coupled wheels 6ft. 8in. with new tyres; the working pressure 175lbs. per sq. in.; and the weight on the rail for each pair of driving wheels is 18 tons.

Driving Axle-Box, fig. 13.—In this design the box is made of gun-metal with four insets of white metal, two narrow ones near the crown and two broad ones on the sides. The box is 14in. wide between the horns and $9\frac{1}{2}$in. deep from the centre to the top. The horn surfaces are $19\frac{1}{4}$in. by $6\frac{13}{16}$in. The keep is of cast-iron, and is supported as shown on two wrought-iron pins $\frac{7}{8}$in. diam. The bearing is $8\frac{1}{2}$in. diam. by $8\frac{7}{8}$in. long, and is eased on the centre line by $\frac{1}{16}$in. as shown. In the top of the box three oil-wells are formed, a long, narrow trough in the middle and a larger cavity ($6 \times 3 \times 2\frac{1}{4}$) on either side. Along the crown of the bearing there is an oil way $1\frac{1}{2}$in. deep and $\frac{7}{8}$in. wide, and the oil is syphoned into this from both the side wells through diagonal holes, one at each end. The central trough is supplied from a brass oil-box $8 \times 3\frac{1}{4} \times 2\frac{13}{16}$ (fig. 14), fixed on to the top of the wheel splasher, through an $\frac{1}{2}$in. copper pipe. The axle-box is also provided with a pad which is pressed against the journal by four vertical spiral springs kept in position by upright rods $\frac{5}{16}$in. diam. riveted into the bottom plate of the frame of the pad, and which rests on the keep as shown on the drawing. The boxes for the coupled axle are the same as those for the driving axle, except that the lower part of the keeps are different because the steel pin of the wrought-iron spring link is $\frac{1}{4}$in. less diam. and because they require only one link $3\frac{1}{4}$in. by $1\frac{3}{4}$in., whereas the driving boxes have two wrought-iron links 2in. diam.

Connecting Rod, fig. 15.—This is 10ft. long between the centres; the big-end bearing is 5in. diam. by $4\frac{13}{16}$in., the crank pin journal being 5in. long; the small end bearing is $3\frac{1}{4}$ by $3\frac{1}{4}$in. The rod is made of forged steel, and is milled in the usual way to a flanged or I section; its depth tapers from $5\frac{1}{4}$in. to $4\frac{1}{4}$in., both

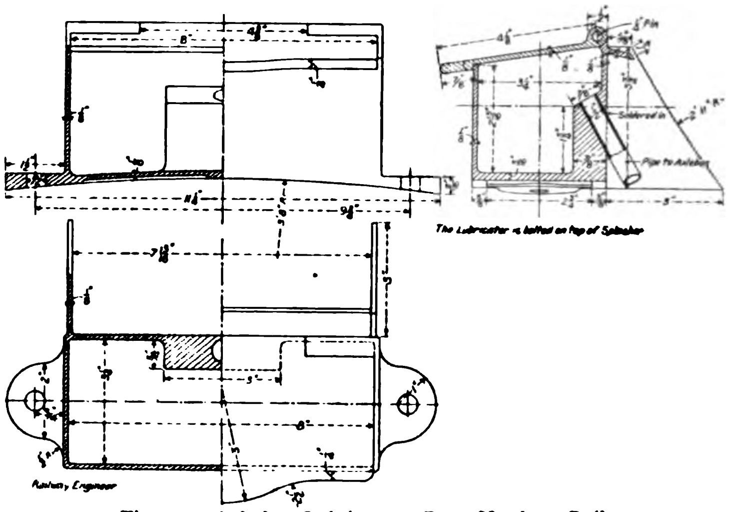


Fig. 14.—Axle-box Lubricator; Great Northern Railway.

* No. I. appeared in February, 1908; No. II. March, 1908.

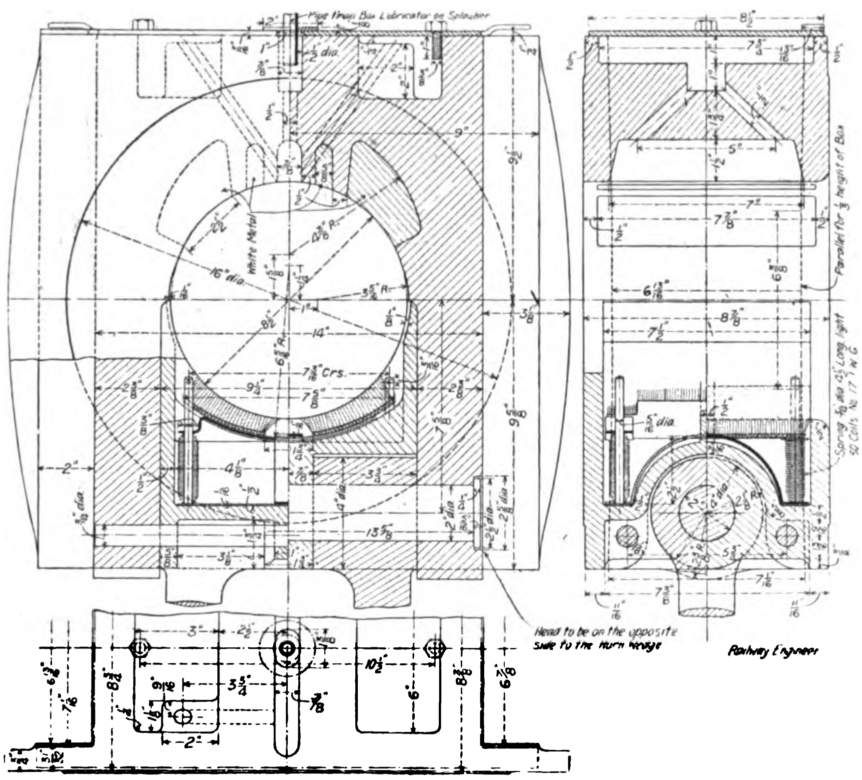


Fig. 13.—Driving Axle-box; Great Northern Railway.

flanges have an uniform section 2½in. by 1⅛in., and the web has a thickness of ⅞in., the outside corners of the flanges are rounded off to a ¼in. radius, and the inside corners to a ⅛in. radius, while the fillets to the web are ⅜in. radius. One of these rods was tested in February, 1904, on the large machine made by J. Buckton and Co. for the French Government, and buckling commenced with a compression of 84 tons.

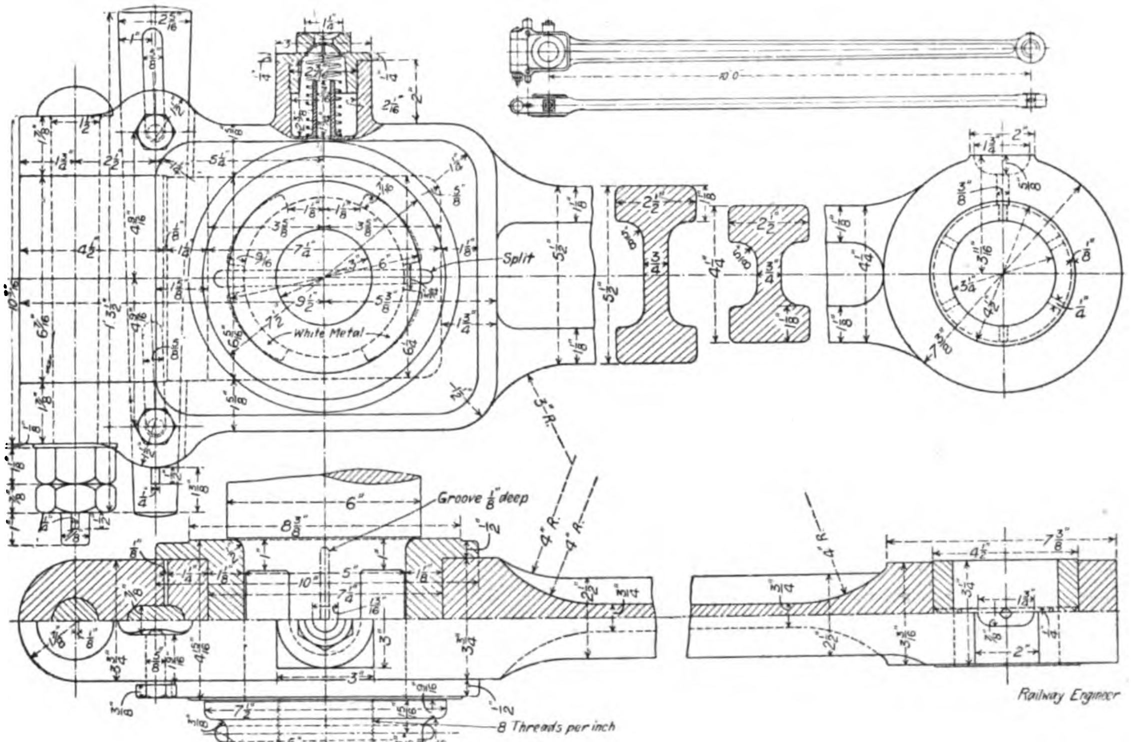


Fig. 15.—Connecting Rod; Great Northern Railway.

is boxed in by the flanges of the bearing. The tapered steel adjusting cotter passes through the keep, and the cotter is secured in position by two steel ⅝ set screws and by a ½ × ¼ split cotter. The keep is held in position by a steel bolt tapering from 1½ to 1¼in. diam. fitted with lock nuts and a split cotter.

The oil cup is solid, with the rod 3in. square bored out to 2¼in. diam. by 2in. deep. It has a brass cap with a filling

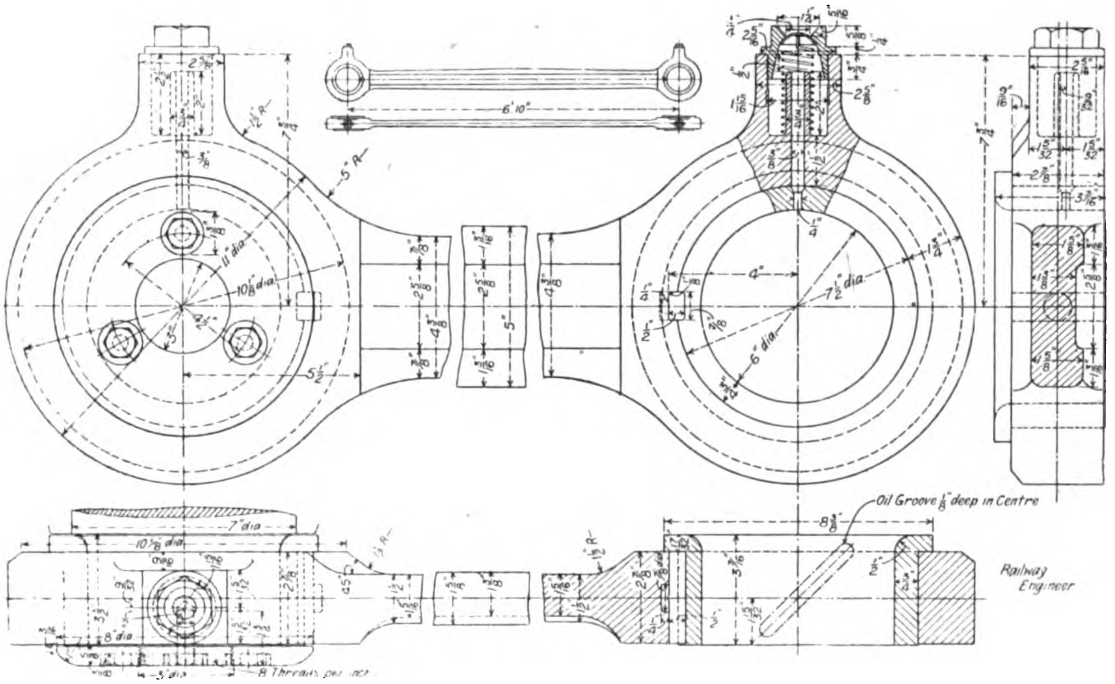


Fig. 16.—Coupling Rod; Great Northern Railway.

The big-end is quite different to any of the other designs we have published. The rod ends in a square mouth, the jaws being 6¼in. apart and 13⅜in. long, into which is fitted the bronze bearing, the back-iron and keep. The back-iron hole closed by a button kep tight by a spiral spring as shown. The feeding hole is $\frac{7}{16}$in. diam., and leads to an oil groove along the top of the bearing ⅛in. deep. The bearing has four large insets about 3¼in. long of white metal, arranged to

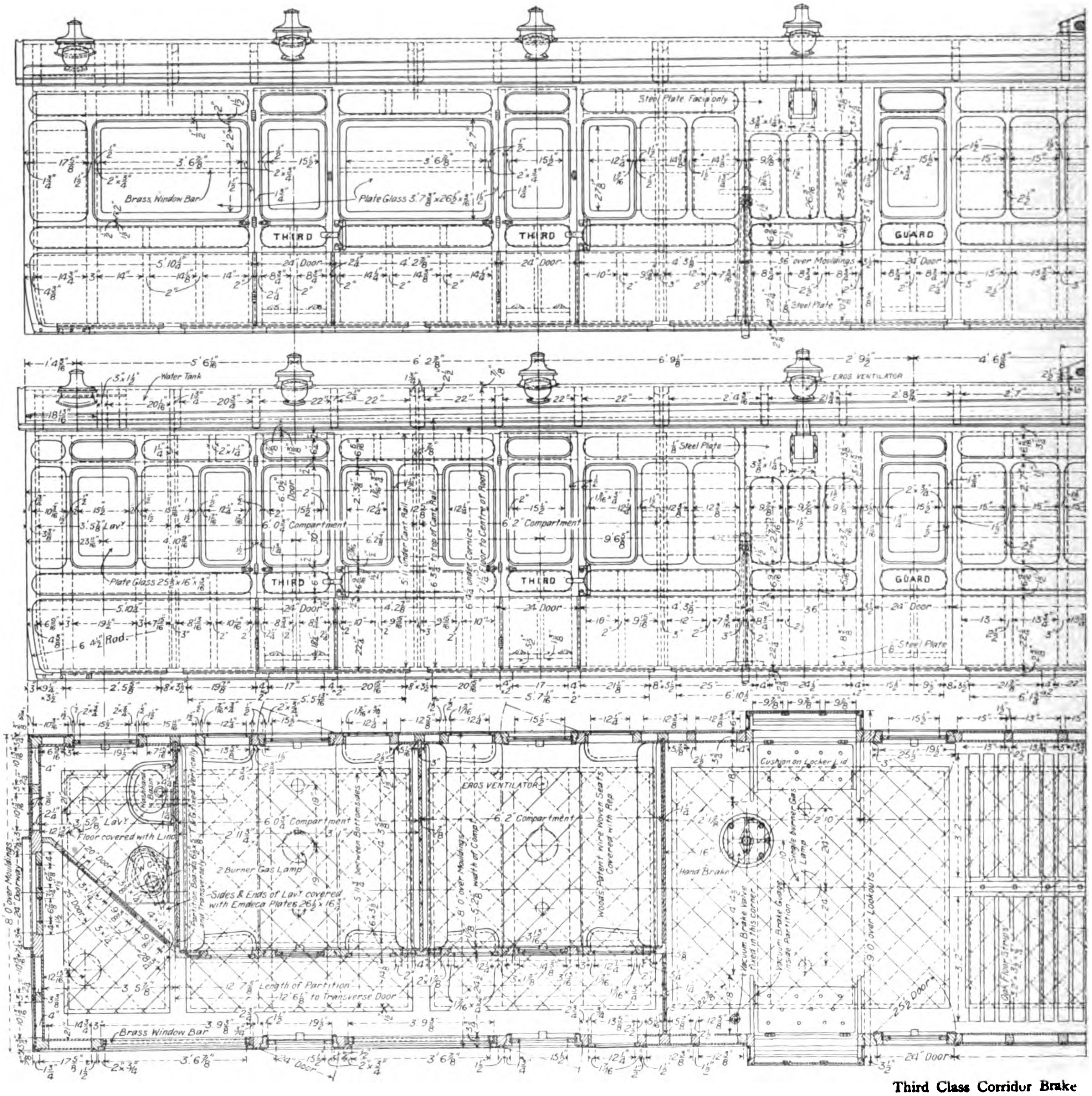
take the thrust and pull as shown.

The big-end is retained on the crank pin by a flanged cap screwed (8 threads to the inch) on to the end of the pin and secured by a taper pin, split at its small end.

The small-end is a plain solid eye $7\frac{3}{8}$in. diam. by $3\frac{3}{16}$in. long, containing a plain bronze bush $\frac{5}{8}$in. thick, and which is not keyed in position. Round its outer central diameter a semi-circular groove $\frac{1}{8}$in. deep is cut, and from this six holes $\frac{1}{4}$in. diam. are drilled through to the bearing surface. There is an oil cup $\frac{5}{8}$in. deep cut out of the rod at the top, and from this a $\frac{3}{8}$in. hole communicates with the circumferential oil-way above mentioned.

Coupling Rod, fig. 16.—This, it will be seen, is, comparatively, a short rod, being only 6ft. 10in. between the centres, and is, in fact, the shortest length possible for 6ft. 6in. wheels, and is only available with the "Atlantic" or 4-4-2 wheel arrangement. The rod is of forged steel, and is nearly solid in section; it is 5in. deep in the middle and tapers to both ends to $4\frac{3}{8}$in., the width being $1\frac{5}{8}$in. at the top and bottom, but the middle is reduced to $1\frac{3}{8}$in. for a depth of $2\frac{5}{8}$in., all on the outer side. The corners are rounded to a $\frac{3}{8}$in. radius and the fillets are $\frac{1}{4}$in. radius.

The bearings are 6in. diam. by $3\frac{7}{16}$in. long (the pin journals being $3\frac{1}{4}$in. long), and consist of flanged bronze bushes



Third Class Corridor Brake

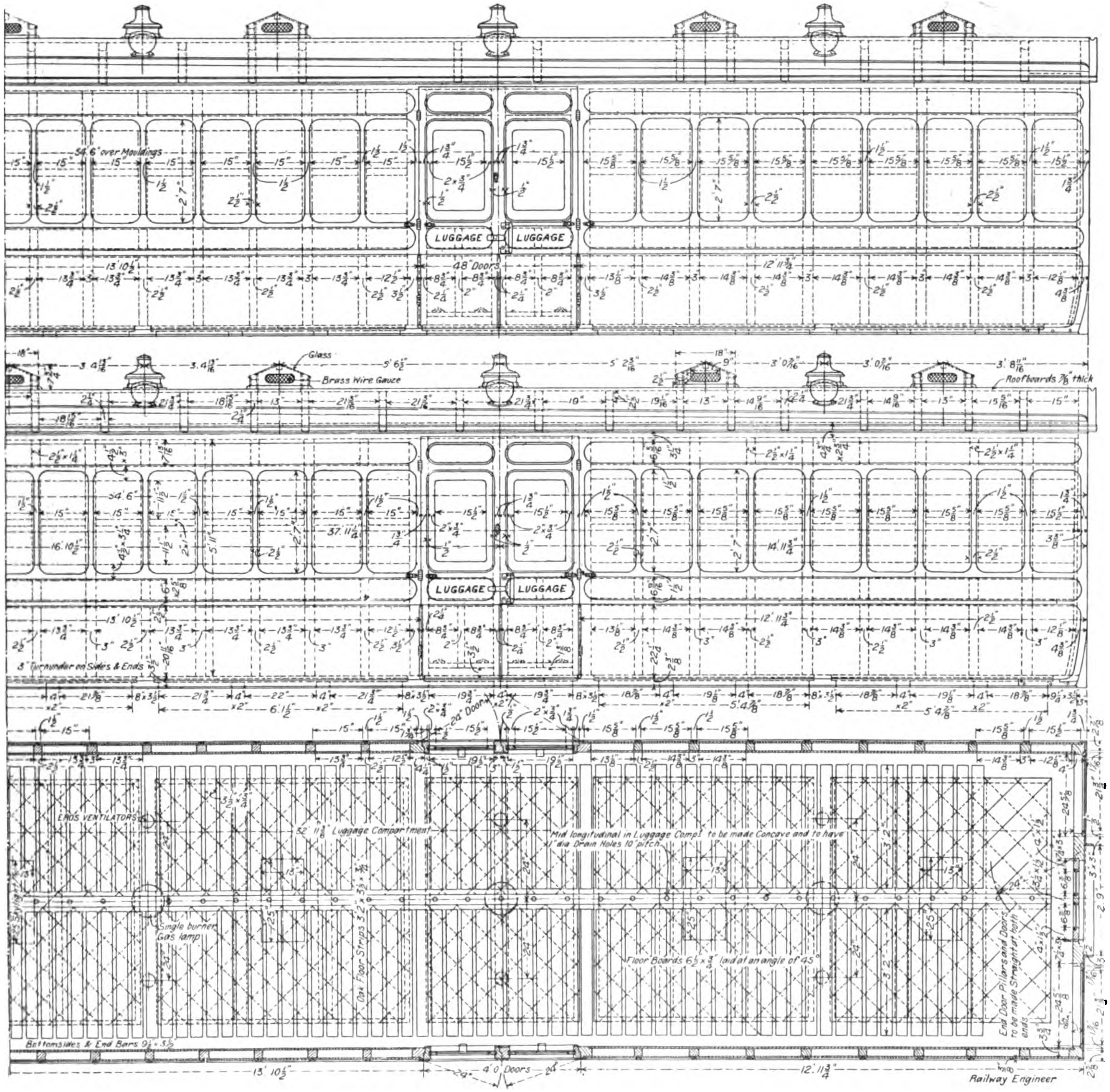
$\frac{3}{4}$in. thick. They are prevented from turning by $\frac{7}{8}\times\frac{1}{2}$ keys having the corners rounded off to an $\frac{1}{8}$ radius, and which have dowel bosses $\frac{7}{8}$in. diam. on them fitting into recesses $\frac{1}{4}$in. deep bored in the eyes as shown. These keys are put in first, and then the bushes forced into their seats. The feed hole, $\frac{3}{8}$in. diam., communicates with a diagonal oil channel $\frac{1}{2}$in. wide in the top of the bearing. The oil cups are solid, and are fitted in precisely the same way as those above described on the big-end of the connecting rod.

The coupling rods are retained on the pins by washers 8in. diam. by $\frac{5}{8}$in. thick. These are screwed on to the end of the pins, which are reduced to 3in. diam. and threaded, 8 to inch, and finally secured by three $\frac{1}{2}$ by $1\frac{1}{4}$ set screws screwed into the pins and their heads let in flush with the surface of the washers.

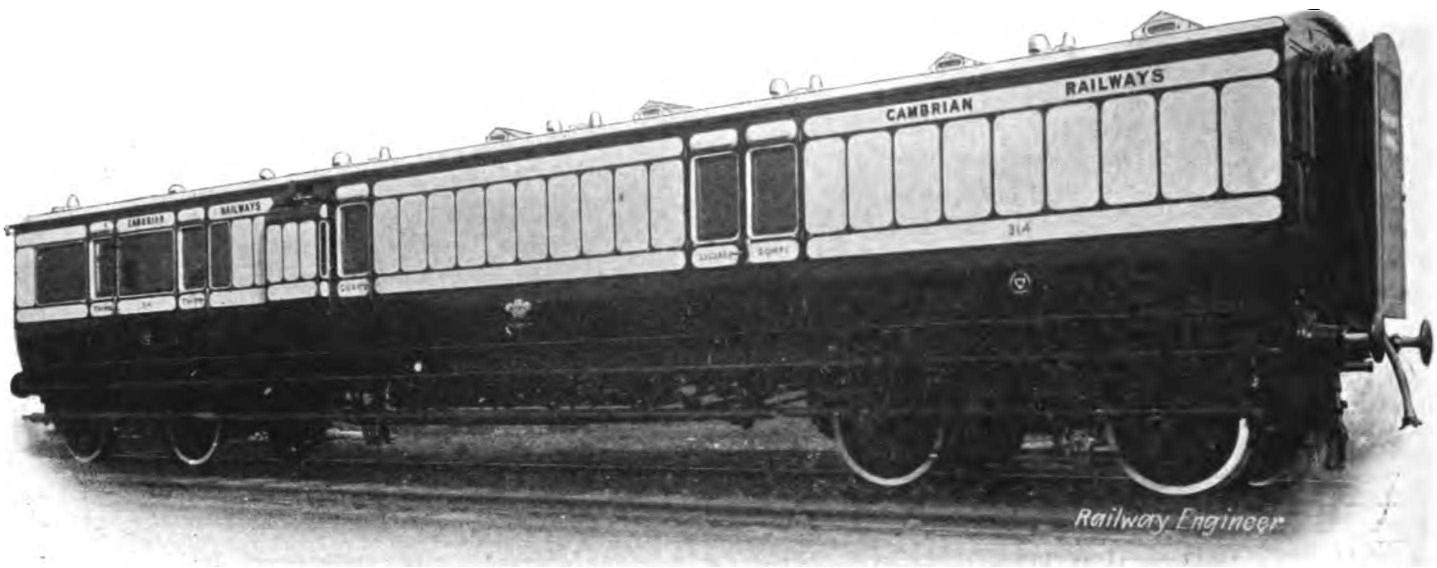
(To be continued.)

3rd-Class Corridor Carriages and Brakes; Cambrian Railways.

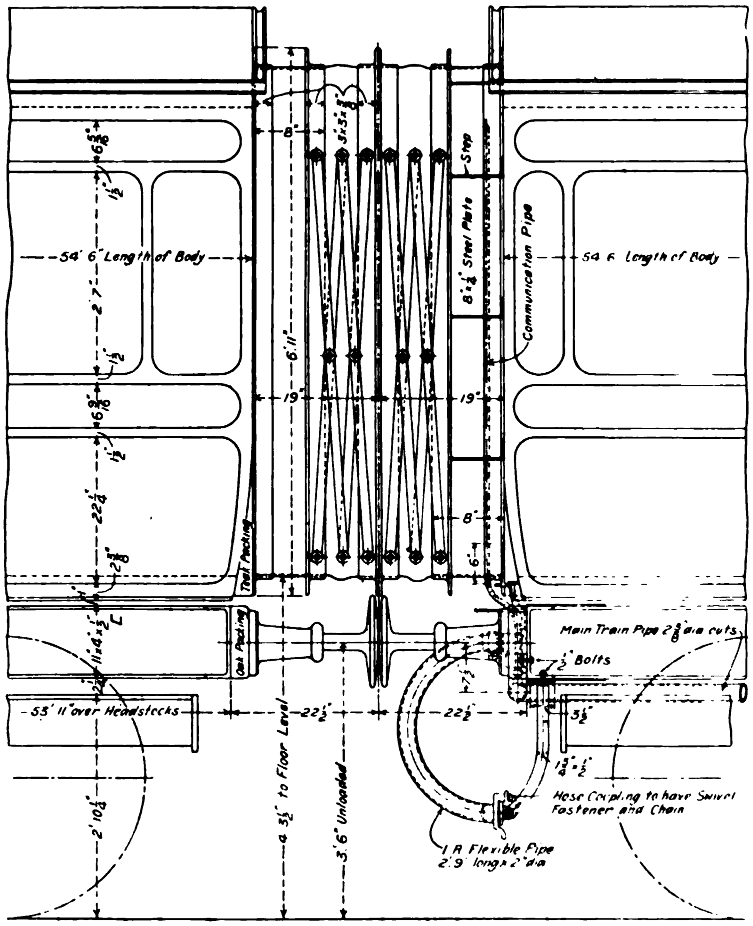
THE latest practice in 3rd-Class Carriages and Brake Coaches on the Cambrian Railways is illustrated by the annexed drawings. The first batch of these vehicles—built to the design of Mr. Herbert Jones, the locomotive superintendent, at the Company's Works at Oswestry—have been put into the service run in connection with the London and North Western R. between Aberystwyth, Pwllheli, and Euston.

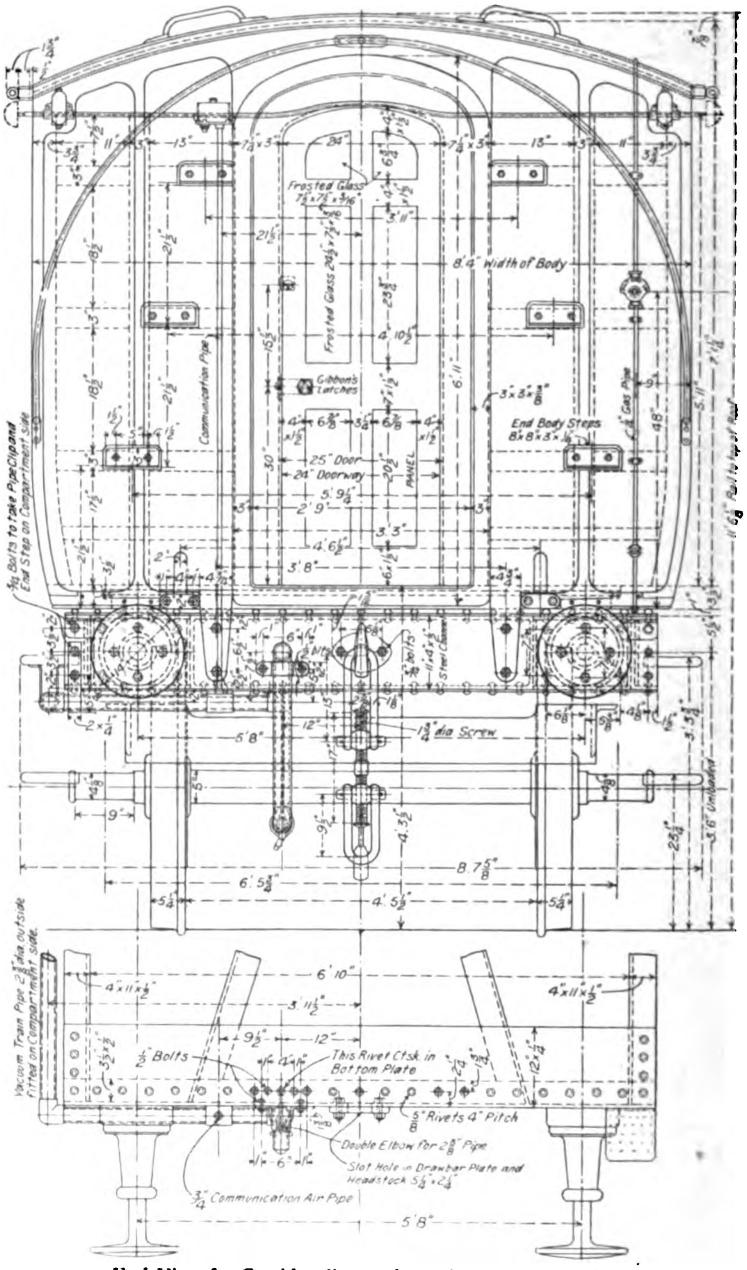


Carriage with Vestibule; Cambrian Railways.



3rd Class Corridor and Brake Carriage ; Cambrian Railways.



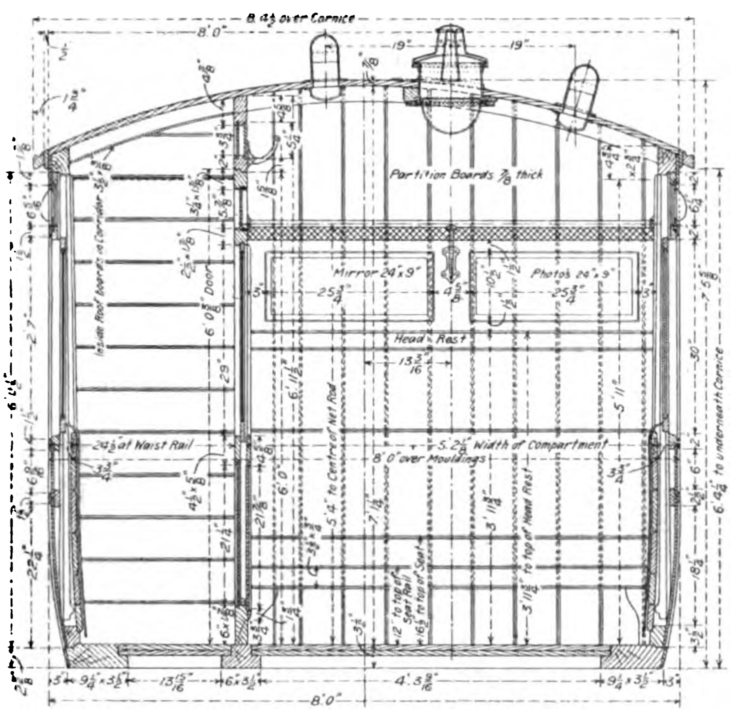


The same design of steel underframe is common to both types, and the Brake Coach is furnished with two additional spiral springs in the bogie centre to carry the extra loading with luggage.

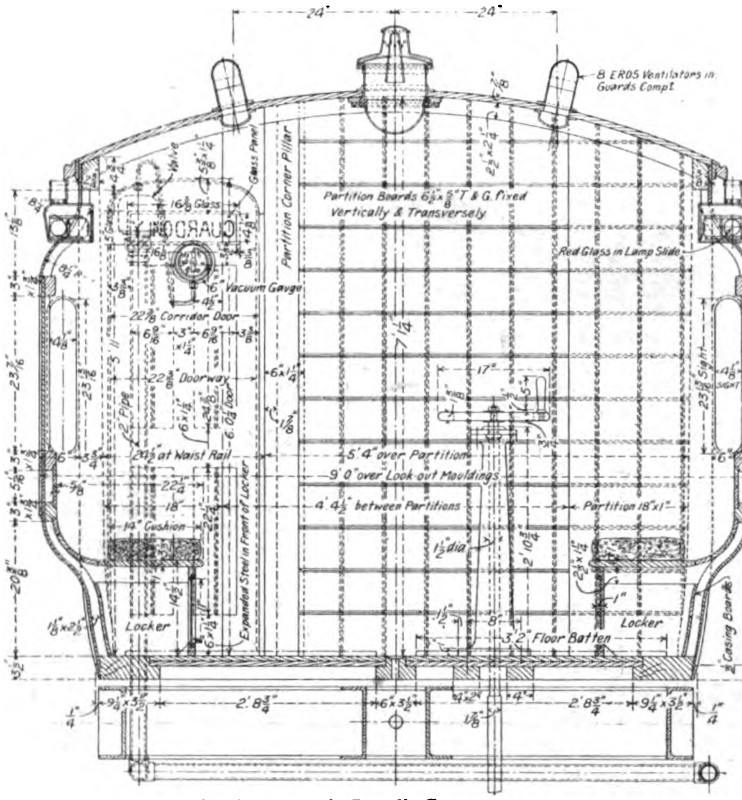
The 3rd-Class Carriages are divided into eight compartments, and a lavatory compartment at one end of the vehicle, while the brake coaches contain two 3rd-class passenger compartments and one lavatory, besides the luggage and guard's compartments.

The principal dimensions are :—Length over body, 54ft. 6ins. ; length over buffers, 57ft. 8ins. ; total wheel base, 48ft. 2ins. ; wheel base of bogies, 8ft. ; width of bodies—3rd-class carriages 8ft. 4ins., brake carriages 8ft., and over look-out

End View for Corridor Composite and 3rd Class Carriages.



Section through 3rd Class Compartment.

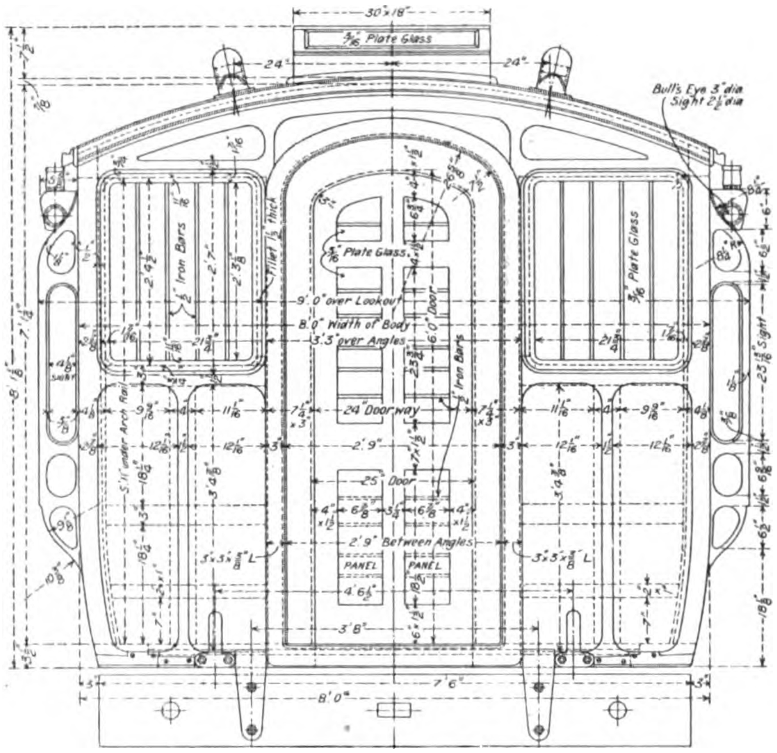


Section through Guard's Compartment.

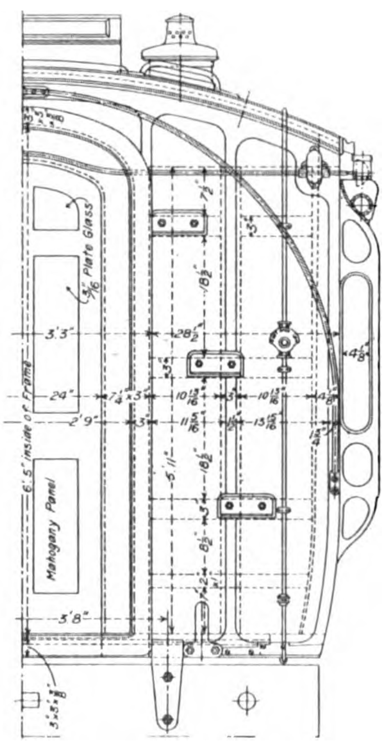
9ft.; height from rail to roof, 11ft. 6⅛ins. The inside dimensions of the compartments are:—Luggage compartment—length 32ft. 11⅜ins., width 7ft. 4½ins., height 7ft. 1¼ins.; 3rd-class compartments—length 6ft. 0⅝ins., width 5ft. 2¼ins., height 7ft. 1¼ins. The corridor has a width of 2ft. 0½in. at waiste rail.

The whole of the body framework, bottom sides and end bars, are constructed of seasoned Moulmein teak, covered with Honduras mahogany panels and mouldings. The corridor is cased throughout with polished mahogany V-jointed match-boards; substantial brass hand rails are carried across the corridor lights, and leather commode handles are fitted to the door pillars. Between the passenger and guard's compartments is a mahogany and teak moulded door, fitted with Gibbon's private locks for the use of the guard only. Ball and socket door stops are fitted to the compartment corridor doors. The roofs of the passenger compartments are formed with V. jointed pine boards, painted white and lined in red.

Wood's patent wire woven seats are used with hair stuffed backs, upholstered in brown figured tapestry, "Eros" ventilators and Wood's ventilator dust shields are fitted in all compartments and corrodor roofs, Peter's patent window blinds, and the usual dust and draught excluders, racks, photographs, Pilkington's bevelled mirrors,



End View at Luggage End.



End Ascending Steps, Commode Handles, Bye-Pass Cock and Communication Signals to be fixed this end of carriage.

End View at 3rd Class End.

3rd Class Corridor and Brake Carriage; Cambrian Railways.

Interior of 3rd Class Corridor and Brake Carriage; Cambrian Railways.

etc. The lavatories are lined with pine boards, on the top of which is cemented enamelled metallic "Emdeca" covering, Doulton white porcelain wash basins and w.c. hoppers are provided, the latter being fitted with mahogany double covers. The water supply is carried in tinned and rivetted copper tanks, and gravitates to the wash basins and w.c.'s, and all the usual fittings being provided. Drawings of the Underframe and Bogie will appear in our next issue.

Destruction of Arch Bridges.*

THE author gave an account of the destruction of some of the bridges on the L. and North Western R. He commenced with the Oxheys and Broughton widening, which was about 3½ miles long, and was carried out at a cost of £50,000.

The blowing up of Lightfoot Lane Bridge, consisting of three brick arches, was chosen for description. "Tonite" was the explosive used on this work. Holes were "jumped" in the haunches and crowns of each arch, the former being charged with 224 ozs., and the latter with 192 ozs. of "Tonite." In addition, holes were "jumped" in the backing over the piers, and charged with 240 ozs. of "Tonite." Instantaneous fuses were fixed to the charges, grouped together and fired by time fuses, care being taken to prevent the charges exploding before their time. Before charging the holes, both main lines were blocked, and the rails, sleepers, etc., removed for safety. Both lines were blocked at 12 o'clock noon and opened again between 4.30 and 5 o'clock p.m.

The crown shots in the centre arch were the first to explode, followed some twenty seconds later by the crown and haunch shots of one of the side arches. A few seconds later the crown and haunch shots of the remaining side arch exploded, and then the shots in the top of the pier, which completed the destruction of the arches. One road was opened after 2½ hours' work, and the other road 1½ hours later; 95 men were engaged.

The cost of destroying this bridge was £200. About 30 yds. to the west of the bridge is situated a chimney 100ft. high, but no damage was caused to it by the explosion.

Then followed the description of a similar work in connection with a widening near Clifton and Lowther, which was 1 mile long, and was carried out at a cost of £8,500. In

*Abstract of a paper by H. C. Duncan Scott read before the Society of Engineers.

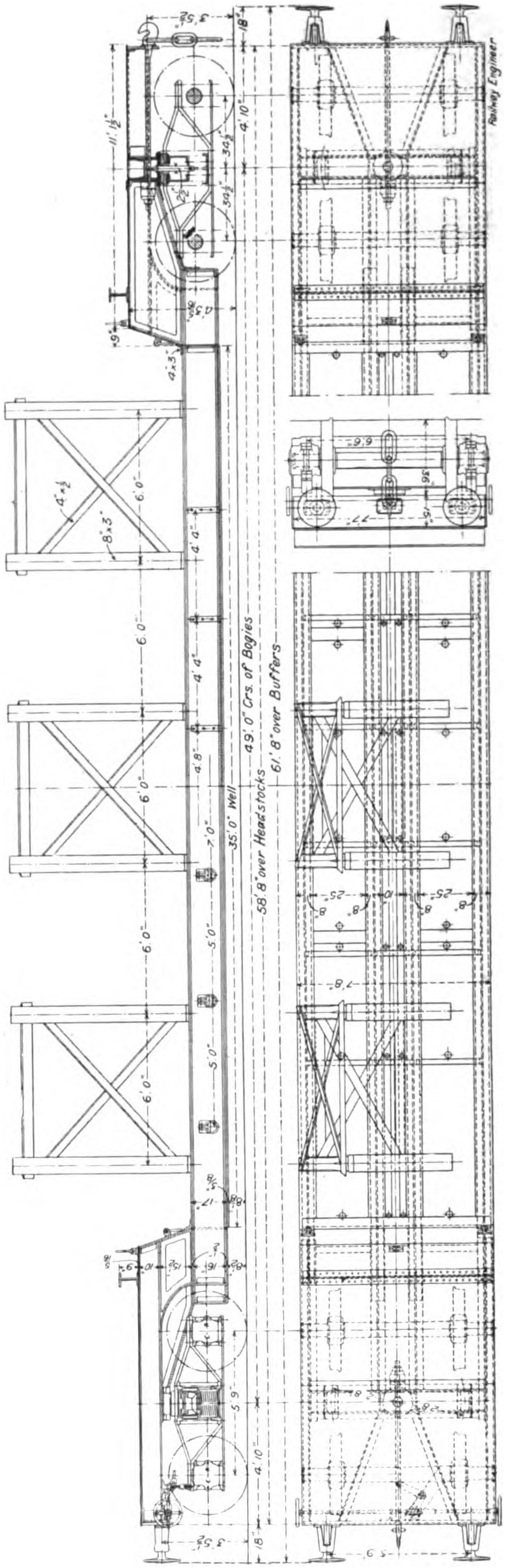


Fig. 3.—30-Ton Trolley; Caledonian Railway.

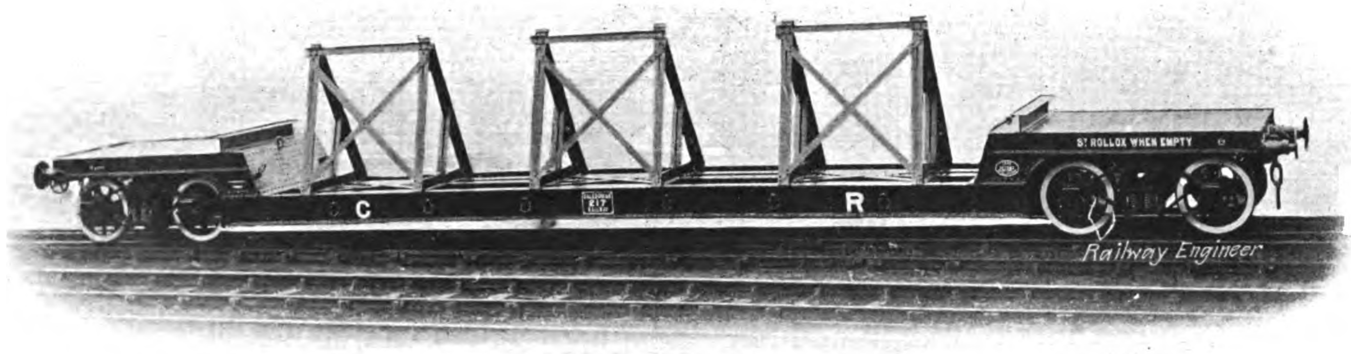


Fig. 1.—30-Ton Trolley ; Caledonian Ry.

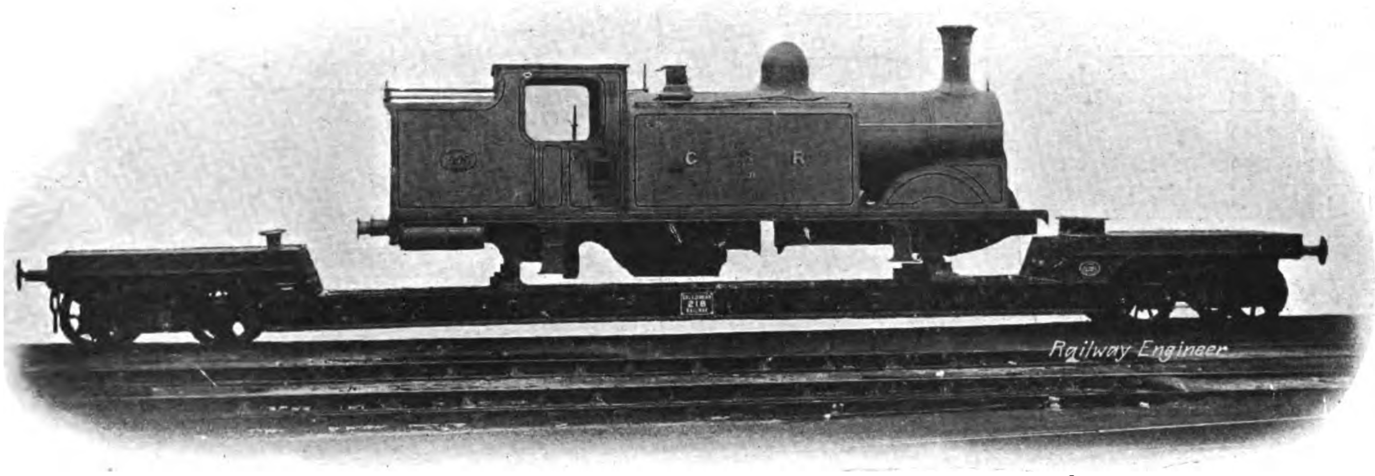


Fig. 2.—30-Ton Trolley, Caledonian Railway, being tested with a load of slightly over 30 tons.

this case the arch to be removed was a masonry one, with a span of 30ft. Holes were "jumped" in the crown, and charged with 9 ozs. of gelignite, the rest of the work being carried out in a similar manner to that in connection with Lightfoot Lane Bridge, the roads in this case being blocked from 10.20 a.m. till 3.37 p.m.

A brick arch bridge of 20ft. span was also intended to be blown up at Preston, but the explosions ("Tonite" again being used) were not successful, and the arch was finally removed by hand. Some of the prices given were of interest, as they are typical for work in the North of England. In cases where explosives cannot be used, the author said the simplest method was to erect centres under the arches, which can then be removed by hand, and if the headway be too small to allow of centres, ribs could be formed of boards bolted together, bent and wedged up to take the form of the soffite of the arch.

30-Ton Trolley ; Caledonian Railway.

THE annexed illustrations show a new type of trolley which the Caledonian R. Co. have recently added to their already extensive stock of "Special class" wagons, and which are intended particularly for the conveyance of armour and other iron and steel plates, castings, machinery, and suchlike consignments of exceptional dimensions and up to 30 tons weight, by ordinary goods trains at usual speeds, and which otherwise could only be carried on Sundays and by blocking the opposite set of rails.

It will be seen from the drawing that the trolley is 61ft. 8in. long over the buffers and 58ft. 8in. over the headstocks by 7ft. 8in. wide. It is carried on two diamond-frame bogies 49ft. apart centre to centre. The wheel-base of the bogies is 5ft. 9in.; the wheels are 3ft. 2in. diam. on the treads and

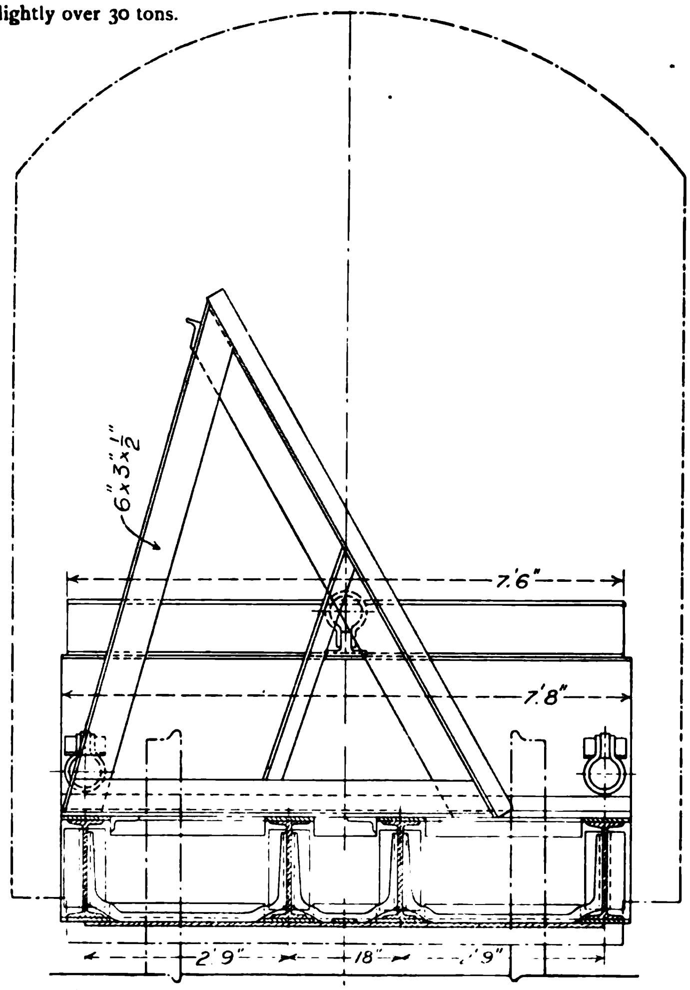


Fig. 4 —Cross Section of 30-Ton Trolley ; Caledonian Railway.

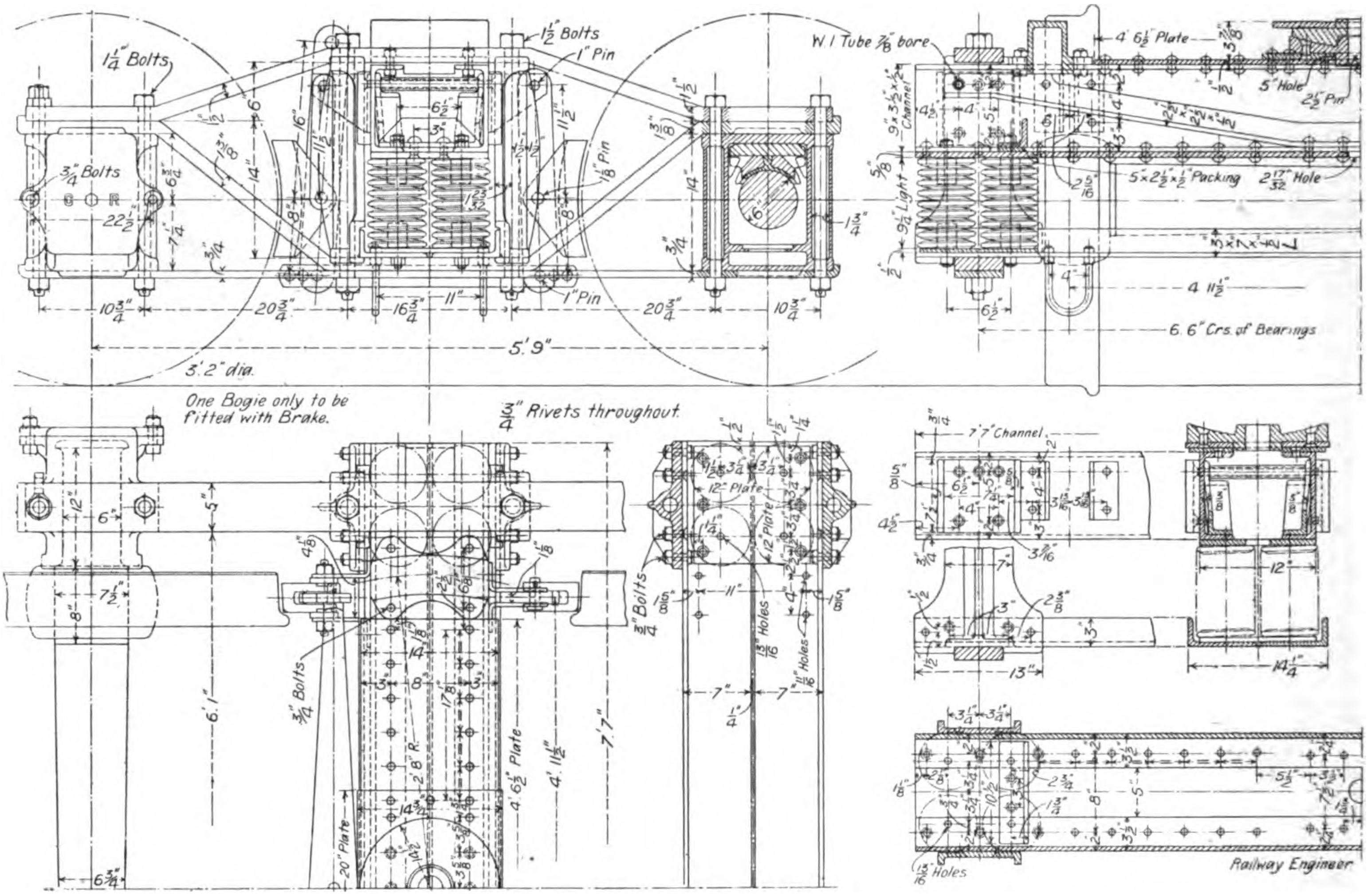


Fig. 5.—Bogie for 30-Ton Trolley; Caledonian Railway.

have cast-steel centres. The journals are 6in. diam. by 12in. long. See fig. 5.

The construction of the platform is simple, the "well" portion consisting of four I section steel girders 16in. by 6in. strengthened by ½in. by 8in. plates riveted to their top and bottom flanges, the latter being connected by a ⅜in. plate for nearly their whole length. The two central girders extend close up to the inside axles, and are placed 18ins. centre to centre in order to allow sufficient side-play for the wheels when taking the sharpest curves. The outside girders are 7ft. centre to centre. The four girders are connected together by six wrought-iron knees—2½ × 1½ rectangular section—riveted to the webs of the girders and to the ⅜in. bottom plate, which extends the whole length of the well. The positions of the knees are shown on the drawing. The ends of the girders are connected by framed angles and plates to the end portions of the platform, which are constructed like an ordinary underframe, the sole bars being 10 × 3½ channels double as far as the bogie centre bearers, and single thence to the ends; the headstocks are 15 × 1¼ plates; the diagonals 10 × 3½ channels; and the whole covered by a 5/16 in. plate.

It will thus be seen that three wells are provided between the longitudinal girders having a clear length of about 35ft.

The vehicle is provided with three trestles constructed of 6 × 3 × ½ angles braced with 4 × ½in. bars as shown. The surfaces against which the load bears are faced with wood planks 8 × 3in. at top and 1½in. at bottom. These trestles are readily altered to face either side or removed altogether if the load does not require them, as shown by fig. 2. The end platforms are fitted with cross I girders 9in. high by 7in. wide, to which a long beam can be attached when carrying certain loads.

An eitherside screw hand brake is fitted to operate on the wheels of one of the bogies, and several shackles for binding chains are provided as shown.

These trolleys were built at the Company's works at St. Rollox to the designs of Mr. J. F. McIntosh, locomotive, carriage, and wagon superintendent, and to whom we are indebted for the drawing and photographs reproduced.

It is of interest to note that the largest plates that are now made measure up to 35ft. by 12ft. 9in., weighing about 8 tons per inch of thickness, and as the bottom of the well is only 10in. above the rail level, such plates can be carried on the vehicles illustrated without special traffic arrangements.

The Netravati Bridge at Mangalore.*

This bridge carries the Madras R. across the estuary of the Netravati River about 2 miles from its mouth, at a point where the width is about 6,200ft. The north bank is well defined by the laterite hills on which Mangalore is built, and the navigable channel, with 17ft. of water, runs close to this bank. The south side of the river is obstructed by sand-banks and islands, and is bordered by low land, which is submerged during the rainy season. The river-bed is coarse sand overlying clay on a very irregular bottom of gneiss.

It was decided by the chief engineer of the Madras R., Mr. H. J. Thompson, to bridge only the deep channel, and

*Abstract of a paper by A. S. Napier, M.Inst.C.E., read before the Institution of Civil Engineers.

by thus contracting the waterway to increase the velocity of discharge and cause the river to deepen itself by scour a plan which has been successfully adopted in dealing with other large rivers crossed by the Madras R.

The bridge consists of 16 spans of 150ft., the girders being of the ordinary I.S.R. type. The two approach-banks, respectively 700ft. and 2,940ft. long, are protected by wing bands on the Bell system, carried up and down the river from the abutments. The piers rest on well foundations, the sinking of which is described, and are built of gneiss masonry set in cement mortar below high-water level, and in surkhi mortar above water.

Two systems of girder-erection were used--floating out on pontoons in the deeper water and erection on staging over the shallower portions of the river, the staging being built of old 60lb. double-headed rails, braced with round iron bars. The processes of erection are described, and the paper concludes with details of the cost, which totalled Rs.1,672,000.

The Locomotive from Cleaning to Driving.—XVI.*

By

JOHN WILLIAMS, *Locomotive Inspector Great Central R.*, and
JAS. T. HODGSON, *Mechanical Superintendent School of Technology, Manchester.*

Lubrication (continued).

Engine failures and traffic delays are often directly attributable to imperfect lubrication, and many systems have therefore been designed from time to time whereby the lubricant may be positively applied to the rolling or rubbing surfaces.

With an efficient system of forced lubrication it is claimed that the metallic surfaces of the bearings and journals are never in contact whilst running, since a film of oil is inserted between the frictional parts, by means of a suitable force pump. In this manner the oil may be delivered at the point the maximum pressure in the bearing, thus reducing wear to a minimum.

In the Tilston's patent system, fig. 48, each bearing contains its own pump, which is so arranged that the oil, after being forced through the bearing, is returned to the reservoir to be used over again. A is a cast iron or other suitable metal bush and B the journal to which is secured the eccentric C for giving motion to the pump plunger F. Oil is supplied through the oil feed K to the chambers D and D[1], which are connected together by the passage E. When the plunger F is at the top of its stroke, the oil in the chamber D escapes through the inlet hole G to the inside of the pump, whence it is discharged on the return of the plunger through the non return valve I and outlet J to the part to be lubricated.

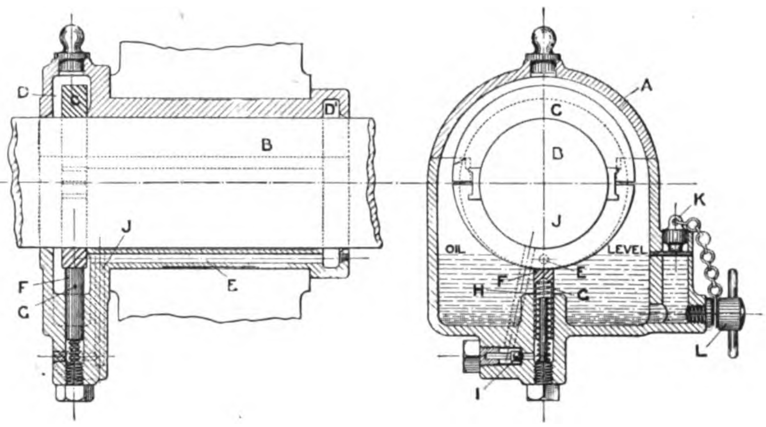


Fig. 48.

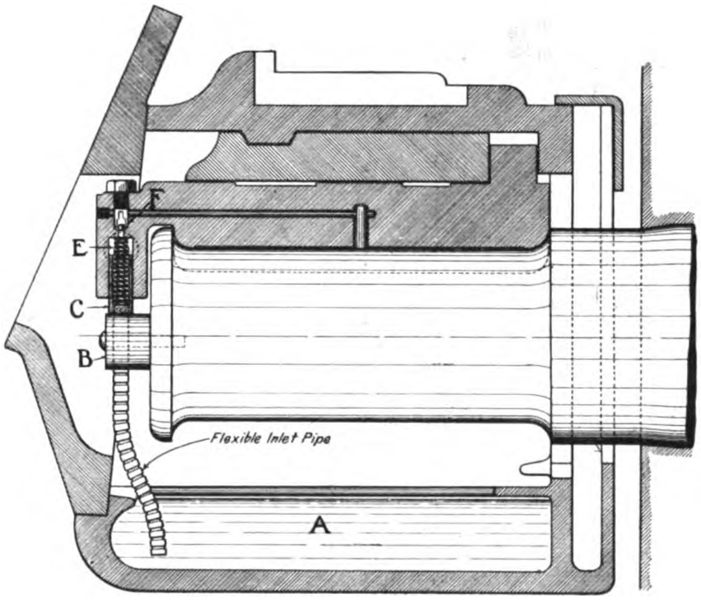


Fig. 49.

From the foregoing description the application of this type of pump to a locomotive axle as shown in fig. 49 will be readily understood.

The patent multiple sight feed lubricator, fig. 50, is

*Copyright. No. I. of this series appeared in February, 1907; No. II. in March, 1907; No. III. in April, 1907; No. IV. in May, 1907; No. V. in June, 1907; No. VI. in July, 1907; No. VII. in August, 1907; No. VIII. in September, 1907; No. IX. in October, 1907; No. X. in November, 1907; No. XI. in December, 1907; No. XII. in January, 1908; No. XIII. in February, 1908; No. XIV. in March, 1908. No. XV. in April, 1908.

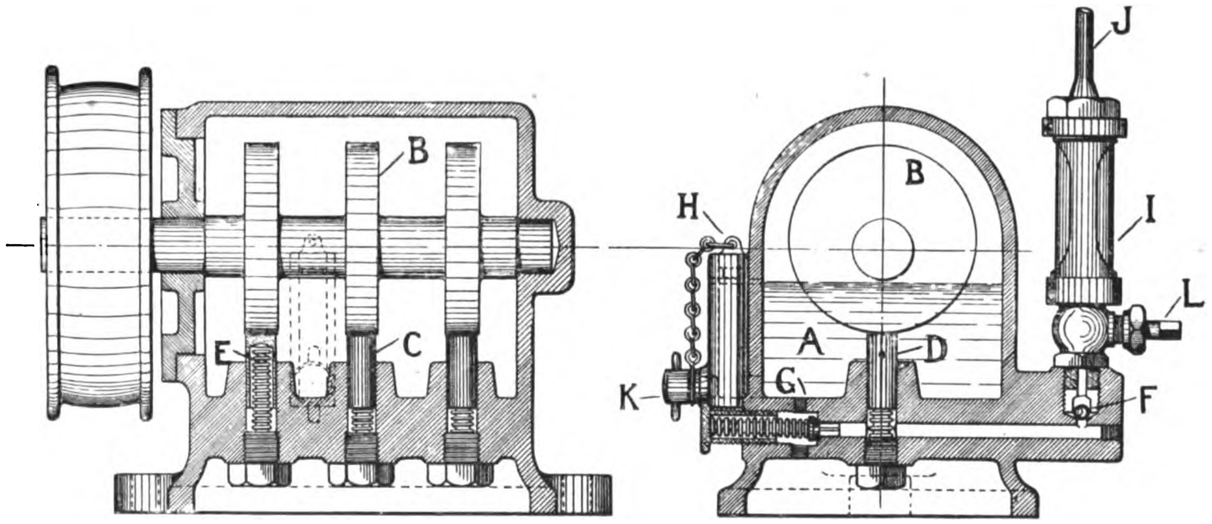


Fig. 50.

intended for use as a central pressure supply, for lubricating the important parts of the engine, such as slide blocks, piston rods, etc. In many instances a single main pump has been used for this purpose, in which case the success or failure of the system is greatly dependent upon the location or adjustment of the parts to be lubricated. The bearing having the longest pipe connection, with the largest number of bends for instance, will not get its proper share of the oil delivered by the pump, since the maximum amount will be discharged through the tubes which offer the least resistance.

With the multiple type of pump, a definite flow of oil can be delivered to any given point, since each pump will work in accordance to the resistance set up in the pipes and bearing to which it is connected.

The Forced Lubrication Co., as sole licensers for the Tilston's patents, are also proprietors of the centrifugal crank-pin lubricator, fig. 51. This is shown for example in its simplest form, but modifications to suit the different circumstances and forms of crank would, of course, be necessary in actual practice. Oil is filled in the chamber A through

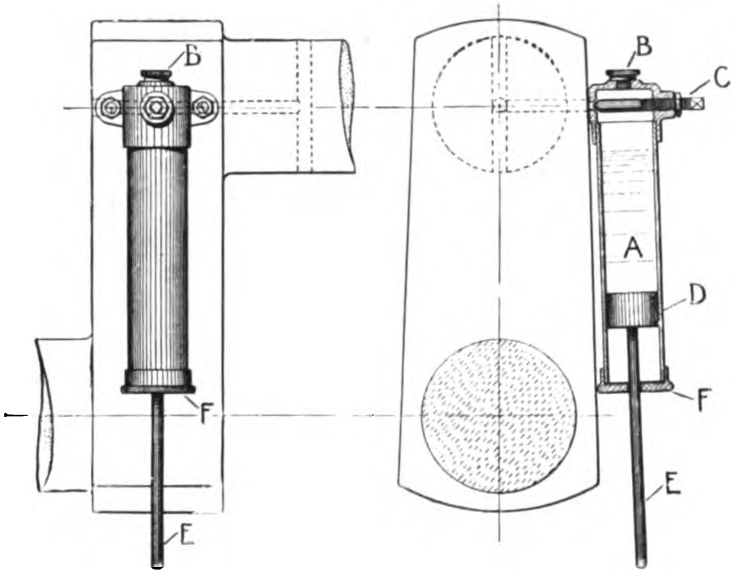


Fig. 51.

B, with the piston D against the screwed cap F. The lubricator is fixed out of centre, to allow the centrifugal force, together with the weight of the piston D, to be exerted upon the body of oil in the chamber A, thus forcing the lubricant past the adjusting screw C by which the amount delivered to the bearing is regulated.

The Westinghouse Quick Acting Brake.

This brake is automatic and continuous and derives its power from compressed air stored in reservoirs under each vehicle in the train. These reservoirs are connected together by a main air pipe, and the brake may be applied by the driver, guard, or passenger, if required; or also be fully applied automatically should the train separate or the apparatus be damaged so as to allow the air to escape.

The air compressing pump (fig. 52) is fixed in a convenient position upon the locomotive. The steam cylinder *A* and compressor *B* together form a direct double-acting air pump, which is under the control of the driver by means of a connection from the cab to the steam cock P. The pump may also be controlled by a governor (fig. 54), which automatically closes the steam supply when the necessary amount of air at the required pressure is stored in the main reservoir C (fig. 55), without any attention on the part of the driver, and a substantial saving in steam be effected, since the pump never works unnecessarily.

The valve motion for the pump cylinder is contained in the top head (fig. 52), which can be quickly removed for repair and replaced by another without the locomotive being

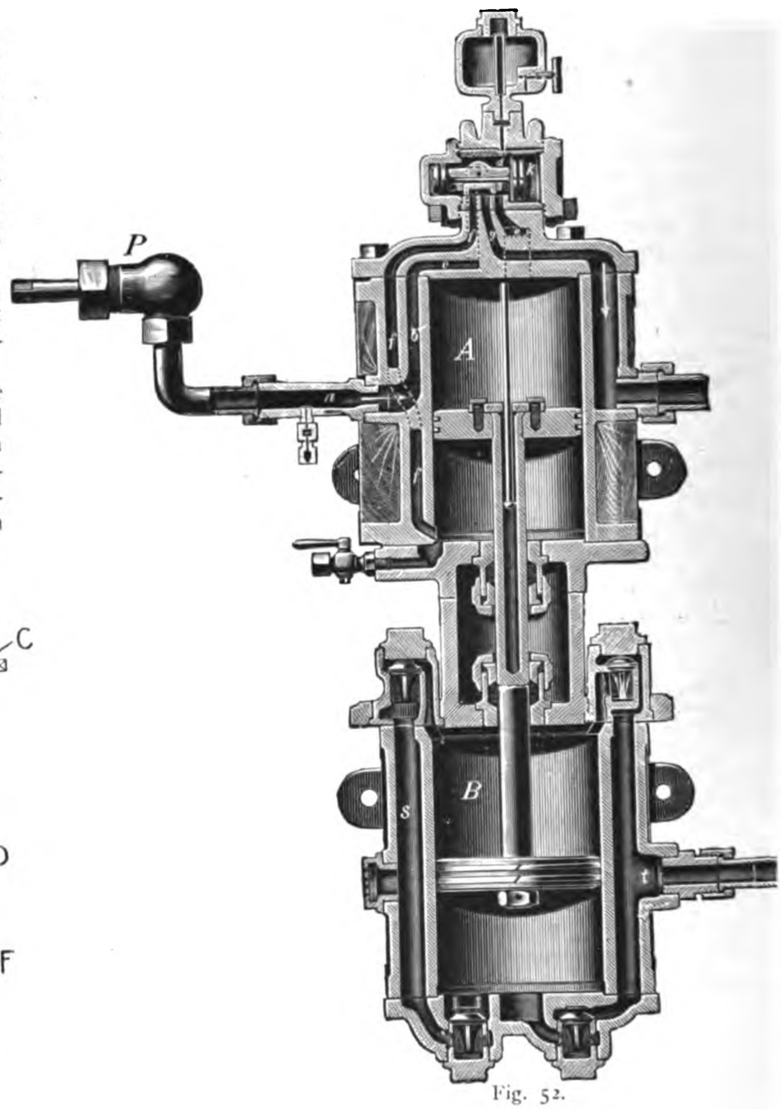


Fig. 52.

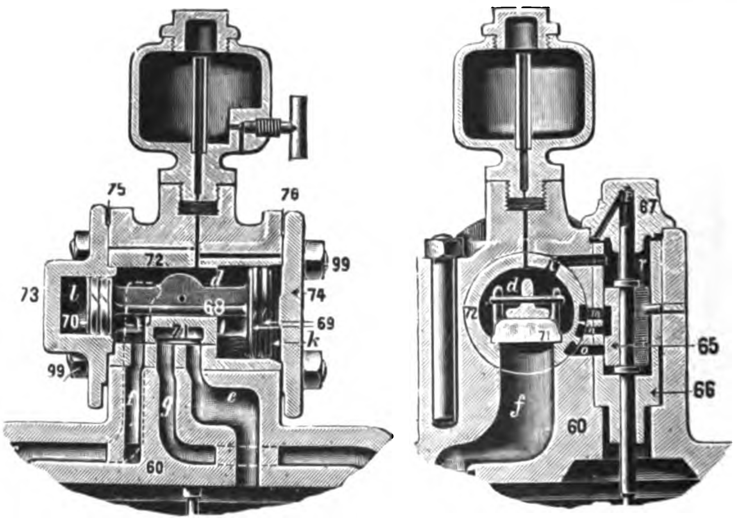


Fig. 53.

put out of service. When steam is admitted to the pump it enters the top cylinder at *a* and flows through the passages *b* and *c* into the main valve chamber *d*, the main ports *e* and *f* being opened for the admission and exhaustion of steam by the movements of the main or distribution slide valve in the head. (Fig. 53.)

The movements of the distribution slide valve, 71, are controlled by a small piston valve, 68, which in turn is actuated through a reversing slide valve, 65, by means of

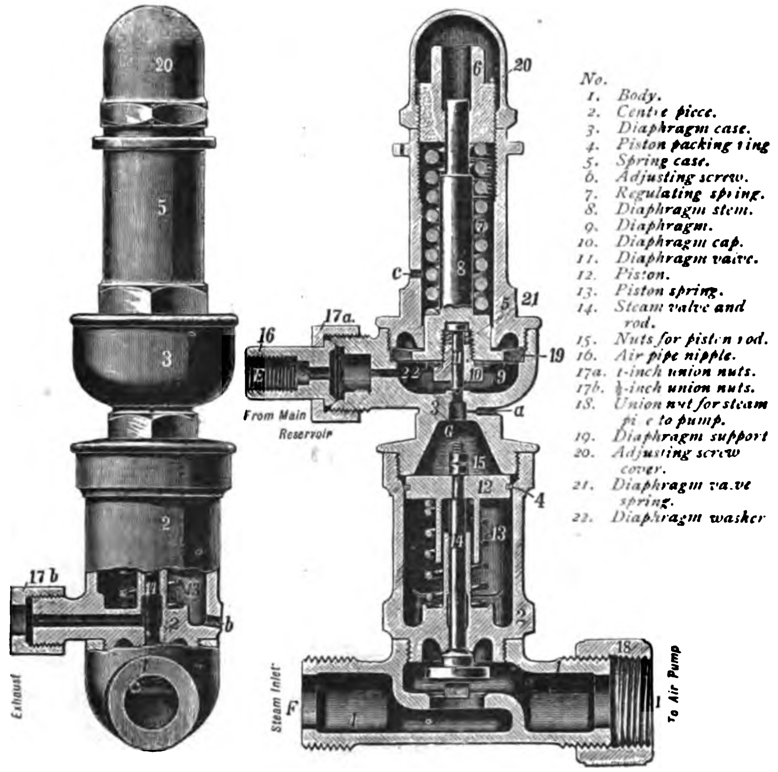


Fig. 54.

the rod working inside the hollow main piston rod, which raises or depresses the valve rod when nearing the completion of its upward and downward strokes.

A central casting containing the glands forms the bottom cover for the steam cylinder and the top cover for the air

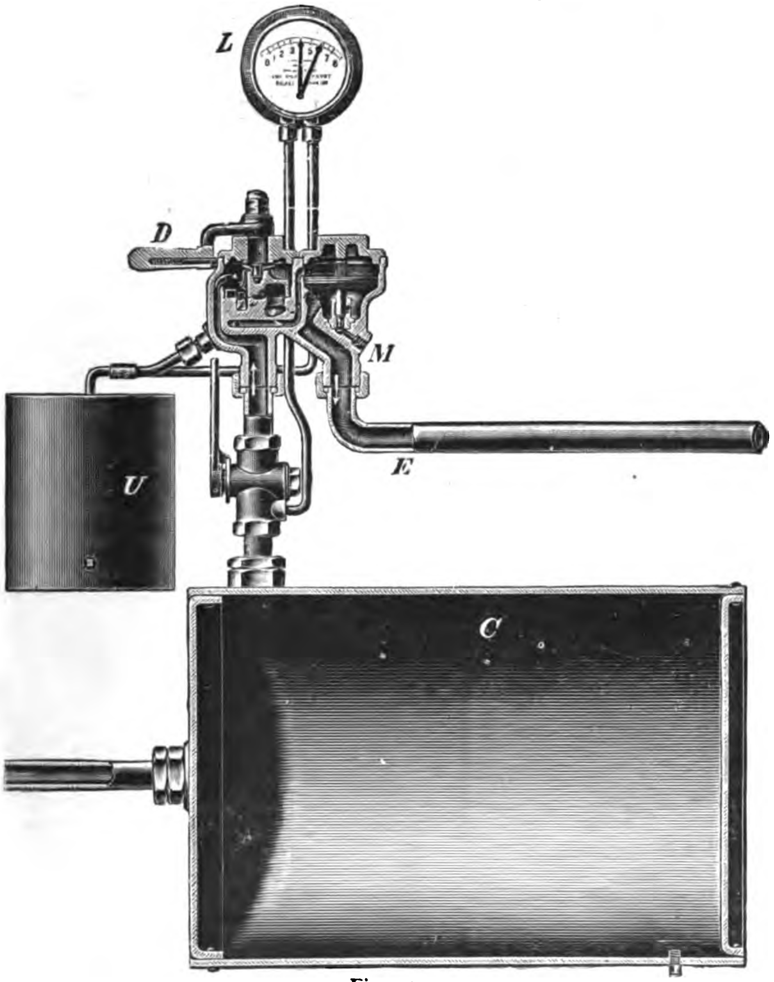


Fig. 55.

cylinder, thus connecting the two together. The main steam and air pistons are both secured to the same piston rod and move together as one piece, so that the whole when complete forms a very compact and serviceable air pump. The air is drawn from the atmosphere through the strainer into the passage *s*, and admitted into the air cylinder by the top left-hand valve at each downward stroke, and the bottom left-hand valve at each upward stroke of the pistons to be discharged by the right-hand valves through the passage *t*

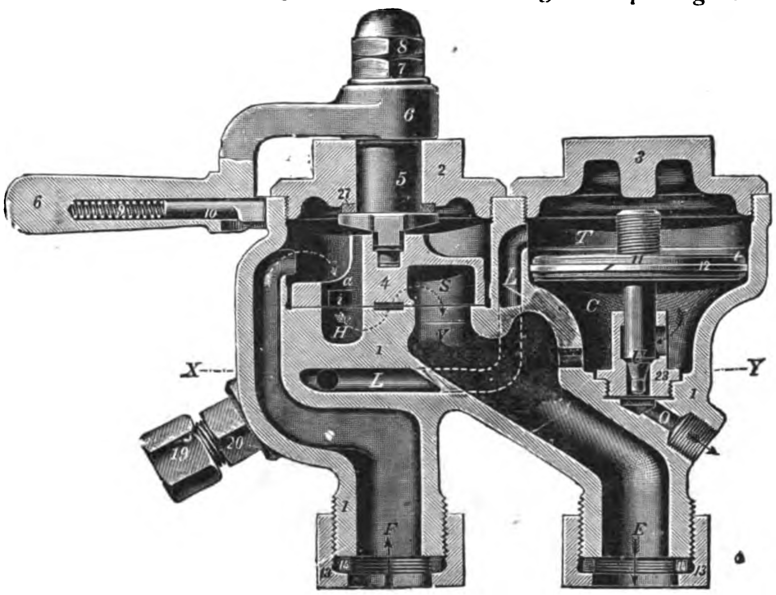


Fig. 56.

to the main reservoir C, fig. 55. This reservoir, which is from 10 to 15 cub. ft. capacity, is usually fixed under the footplate, and is charged with air to a pressure of from 90 to 95 lbs. per sq. inch, to be used for charging the main pipe E as required for releasing the brakes, or to charge the auxiliary reservoirs located on the engine, tender and vehicles. On some railways, notably the Great Eastern, the casting forming the footplate is used as the main reservoir.

With 140 lbs. steam pressure the 8ins. by 8½ins. pump, when in good condition, will compress from 0 to 95 lbs. pressure of air in a standard main reservoir of 10 cub. ft. capacity in 100 seconds. A ball or globe lubricator is fitted to the steam supply pipe, so that the oil is carried forward by the steam to lubricate the piston rings, rods and valve motion in the cylinder and steam chest. The globe valve

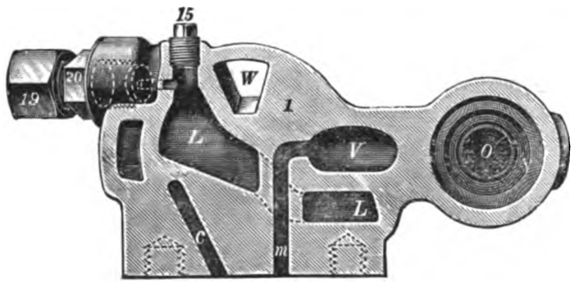


Fig. 57.

is filled with cylinder oil before the pump is started, and should last without refilling for from 7 to 10 hours. The oil is fed by displacement, as already described, so that the condensation should be drained by the cross-handled plug valve before refilling the lubricator. The small tap below the lubricator should be open for draining the pipes when the pump is shut off. With the air supply a small quantity of moisture as well as grease from the air cylinder of the pump is frequently carried into the reservoir C and there deposited. To provide for the removal of such deposits a suitable drain plug is placed at the bottom of the reservoir, which must be unscrewed for the purpose at lease once a week.

The Driver's Equalising Brake Valve (figs. 56, 57, 58 and 59) is the valve by which the driver operates the brake. It is placed in the cab of the engine, so that it can be manipulated without the driver moving his position. It is specially designed to work the brake in the best possible manner, particularly on long trains, and is provided with a device to counteract the effects of rough or unskilful handling. The rotary valve 4 controls the passages leading from the main reservoir C to the main pipe E, and the brake valve reservoir U (fig. 55). In ordinary applications of the brake by the driver the small equalising piston T, in conjunction with the equalising brake valve reservoir U, automatically controls the discharge of air from the main pipe E so as to provide for a uniform reduction of the pressure in the pipe. The five principal positions of the valve handle for working the brake, as shown in fig. 59, are as follows:—

(i.) Position for Charging and Releasing the Brakes. When in this position compressed air from the reservoir C flows through the brake valve into the small reservoir U, and also into the main pipe E.

(ii.) Position whilst Running. In the second position the supply to the main pipe E is cut off, and another port is opened, which leads to a small feed valve. This valve is held upon its seat by a spring having a resistance of about 25 lbs. per sq. inch, so that when the pressure in the main

Fig. 58.

pipe E, with the added load of the spring, is equal to the pressure in the reservoir C the feed valve is closed, and thus cuts off the communication between the reservoir and the brake pipe. If, however, there is any leakage from the train pipe, the pressure in the reservoir will automatically open the valve, thus maintaining the proper working pressure in the train pipe. By means of the load exerted by the spring upon the feed valve a pressure of 25 lbs. in excess of that in the train pipe is retained in the main reservoir, to be used as occasion requires.

(iii.) Neutral Position. In this position all the ports in the rotary valve are closed.

(iv.) Position for Ordinary Application of the Brake. When in this position the air from the chamber T is allowed to escape, and the equalising piston 12 is forced upwards by the excess pressure underneath, thus lifting the discharge valve from its seat. Air is therefore allowed to escape from the main pipe E through the exhaust passage O until the pressure in the pipe throughout the train is equal to that retained in the chamber T, when the valve u is returned to its seat by the gravity of the equalising piston, which has thus been placed in equilibrium.

(v.) Position for Emergency Application. When the valve handle is turned beyond the position iv. towards the right, a direct communication between the main pipe and the atmosphere is established, thus allowing the air to escape from the main pipe E with great rapidity, the brakes being instantly applied with full power.

The main pipe E extends the whole length of the train, being connected by flexible hose couplings between the

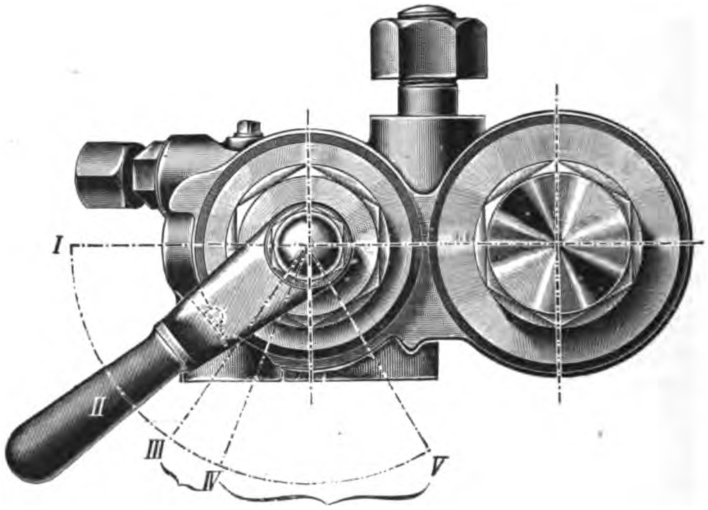


Fig. 59.

different vehicles. The brakes are applied to all the vehicles by a reduction of pressure in this pipe whether purposely or accidentally produced. In ordinary working this is effected by allowing air to escape at the driver's brake valve. The brakes are released by admitting air from the main reservoir C through the driver's brake valve, and thus increasing the pressure in the pipe.

The locomotive tender and each braked vehicle are provided with an auxiliary reservoir G (fig. 60), in which compressed air supplied from the main reservoir C is stored. In the Standard Quick-acting Brake the auxiliary reservoir G, triple valve F, and brake cylinder H are bolted together to form one piece.

Each brake cylinder contains a piston having its rod attached to the brake gear. So long as the brake is not applied the cylinder is free from air pressure, and the piston is in the position shown. When, however, the brake is put into operation, compressed air is admitted to each cylinder by the triple valves F. The air pressure acting on the piston forces the latter forward, thus applying the brake blocks to the wheels. Upon the air being allowed to escape from the cylinder, the piston spring, which has been compressed in applying the brake, extends and returns the piston and brake gear to their original positions, thereby releasing the blocks from the wheels. The triple valve F forms the most essential part of the Westinghouse brake apparatus. It is operated by the variations of pressure in the main pipe E in such a manner that it automatically admits compressed air to the brake cylinder of the vehicle to which it is attached, whenever the pressure in the main pipe is reduced, and discharges the compressed air from the brake cylinder, when the original pressure from the main pipe is restored. If the

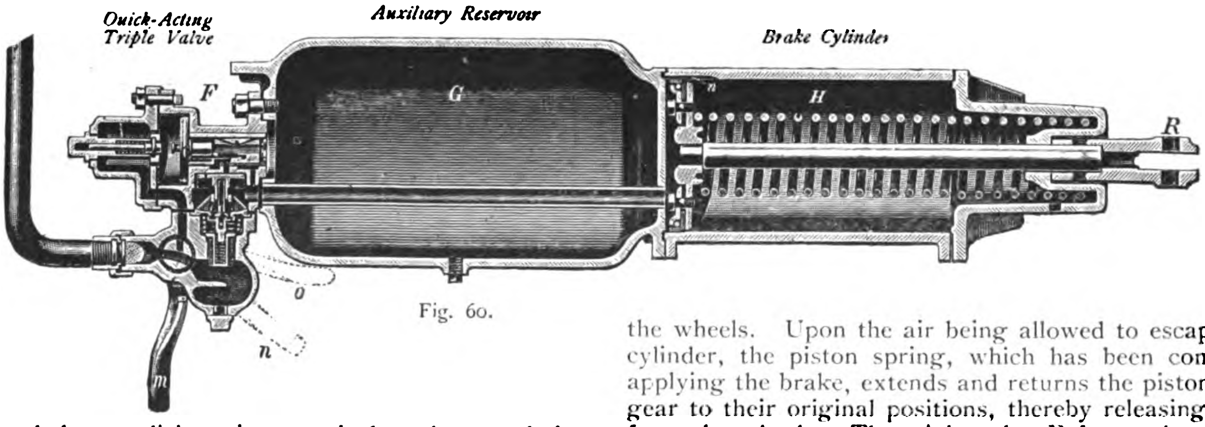


Fig. 60.

air is allowed to escape slowly from the main pipe E an ordinary application of the brake is obtained, each triple valve permitting a portion of the compressed air stored in the auxiliary reservoir G to flow into the corresponding brake cylinder, thus forcing the piston forward and applying the brake. The brake force thus produced corresponds to the reduction of pressure in the main pipe E. The driver can therefore graduate the action of the brake at will by regulating with the brake valve the discharge of air from the pipe. If, however, the air is rapidly discharged from the main pipe E, as in an emergency application of the brake, a sudden reduction of pressure in the pipe will take place, and thereby instantly produce the rapid action of the brake. The triple valves F then not only allows compressed air from the reservoir G to enter the brake cylinders H, but in addition opens on every vehicle a large communication through which compressed air is also admitted from the main pipe E into the brake cylinders H. A double advantage is thereby obtained, first in utilising a considerable portion of the air in the main pipe to increase the brake force in emergency, and secondly in producing a rapid reduction in pressure in the whole length of the main pipe, which accelerates the brakes and practically insures simultaneous action throughout the train.

In releasing the brakes by the air admitted from the main reservoir C through the driver's brake valve to the main pipe E, the pressure is restored, which causes the triple valve to discharge the air from the brake cylinder H into the atmosphere, thus relieving the brake blocks of pressure, and also re-charging at the same time the auxiliary reservoir G. To prevent the application of the brake from slight leakage in the main pipe, each brake cylinder is provided with a small groove n which establishes communication between both sides of the piston when the brake is not applied. If on account of such leakage a slight flow of air to the brake cylinders should occur, the air would pass through the groove n to the atmosphere without moving the piston. When, however, a considerable quantity of air is admitted to the cylinder, as in the ordinary application of the brake, the piston is immediately forced past the groove, and an escape from the cylinder is thus prevented. In order to insure that the pistons of all the brake cylinders in the train completely clear the corresponding leakage grooves, the driver should always reduce the pressure in the main pipe by at least 6 or 8 lbs. whenever he puts the brake into operation. Care must also be taken that on every vehicle the brake gear is so adjusted that it allows the piston to travel sufficiently far.

The pressures indicated by the two pointers on the duplex gauge attached to the brake valve on the engine should be 90 to 95 lbs. in the main reservoir C, and 70 lbs. in the main pipe E, an excess of pressure in the main reservoir being thus available for quickly releasing the brakes, and also for re-charging the auxiliary reservoir G. The 90 lbs. pressure should be pumped into the main reservoir before the engine is attached to the train, and the main pipe E under the engine should always be blown out by opening the coupling cock at the back of the tender a short interval before the couplings between the tender and train are united. When the locomotive is coupled to a train carrying less air pressure the brakes on the engine and tender will be automatically applied, as the pressure in the main pipe of the engine will be reduced by the discharge of air into the train pipe. If, however, the driver has been careful to come up to the train with 90 lbs. in the main reservoir the brakes will be released when the train pipes are properly charged. To charge the brake apparatus on the vehicles the handle on the driver's brake valve should be placed in the "Release Position" (i.) and kept there until the main pipe and auxiliary reservoirs are charged with an air pressure of 70 lbs. When this pressure is indicated on the gauge the handle of the brake valve should at once be turned to the "Position whilst Running" (ii), where it must usually be kept. The air pump should be set to work when the train is charged, and should be kept going until a pressure of 90 lbs. is obtained in the main reservoir. To retain these pressures the importance of having the brake couplings properly united and all joints in good working order will be evident. The brakes should therefore be tested, by being applied a short time, to see that they operate properly on all the vehicles before starting from the terminus, or from any place where the hose couplings have been separated and re-coupled. Whilst the train is running unbraked it is important that the handle of the driver's brake valve should always be kept in "Position whilst Running," so that the 25 lbs. excess of pressure may be maintained in the main reservoir for ensuring a prompt and quick release of the brakes. The air pressure in the main pipe should not exceed 70 lbs., otherwise the excessive pressure may cause trouble and delay, especially when vehicles are detached and coupled to other trains. After a certain amount of practical experience the driver will know when to apply the brakes at a sufficient distance from the stopping point by turning the handle between positions iii. and iv. to obtain the necessary 6 to 8 lbs. reduction of pressure in the main pipe. This reduction is required to ensure the brake cylinder pistons being clear of the leakage grooves, after which a very small reduction of pressure in the main pipe will serve to gradually increase the brake power as circumstances may require. The brakes, however, are fully applied when a reduction of 20 to 25 lbs. pressure has been effected in the main pipe, so that it is useless to discharge any further quantity of air. Drivers should always bear in mind that less brake power is required for stopping from a low than from a high speed, and that the brakes should not be so forcibly applied as to skid the wheels.

For ordinary stops the handle of the brake valve should not be turned beyond "Position iv.," since this would produce the quick action of the brakes, which should not be employed except when absolutely necessary to avoid an accident. For quick stops, as in cases of emergency, the handle of the brake valve should be turned as far as possible to the right, "Position v.," when an instantaneous application of all the brakes with full force is produced. If the brakes should be applied from the train, either by the guard or automatically by the rupture of a hose coupling, etc., the driver must at once aid in stopping by turning the brake valve handle towards the right, as in ordinary applications, which will also prevent the escape of air from the main reservoir. To control the train on descending grades the brakes should be lightly applied before too high a speed is reached, and the brake force should then be gradually increased as needed to keep the speed uniform. If the brake force should become too high the brakes may be released on the engine and tender by gradually opening the release valve, which is fixed in the cab within easy reach of the driver. In releasing the brakes the brake valve handle should be kept in the "Release Position" (i.) for a sufficient length of time to properly recharge the auxiliary reservoirs. When two engines are coupled to a train the brakes should be entirely under the control of the driver of the front engine, and the main reservoir of the second engine must then be isolated from the main pipe of the train. For this purpose a cock, known as the brake valve isolating cock, is placed in the pipe leading from the main reservoir to the driver's brake valve.

In ordinary working this cock should always be open, but when two engines are employed for working a train the isolating cock on the second engine must be kept closed and the handle of the brake valve put in full release position for so long as the driver of the leading engine is in charge of the brakes. The air pump on the second engine should be worked to maintain the maximum pressure in the main reservoir, so that the driver may be ready at any time to take charge of the brakes if necessary.

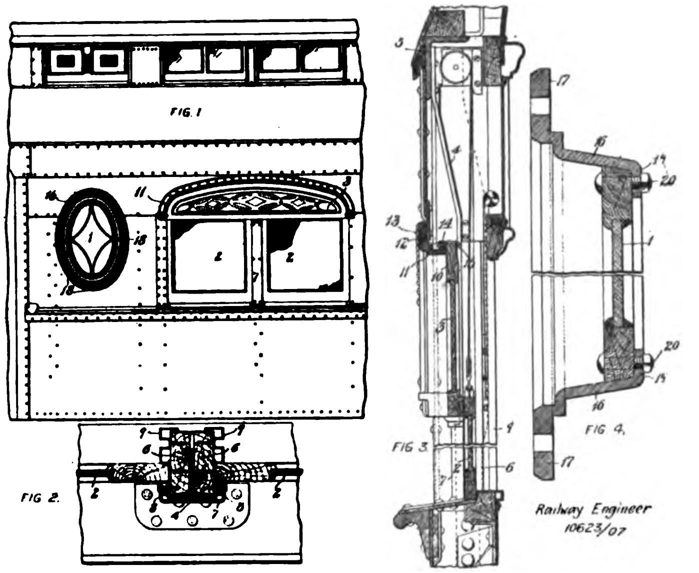
The foregoing points will be of assistance when "learning the brakes"; but practical experience combined with intelligent perseverance is absolutely essential in mastering the numerous details connected with the working of this or any other continuous brake. The best methods to adopt for

the different operations, as when attaching or detaching vehicles, etc., and the necessary knowledge for the proper maintenance of the brake apparatus on the engine and tender, can only be learnt by time and experience.

Recent Patents relating to Railways.

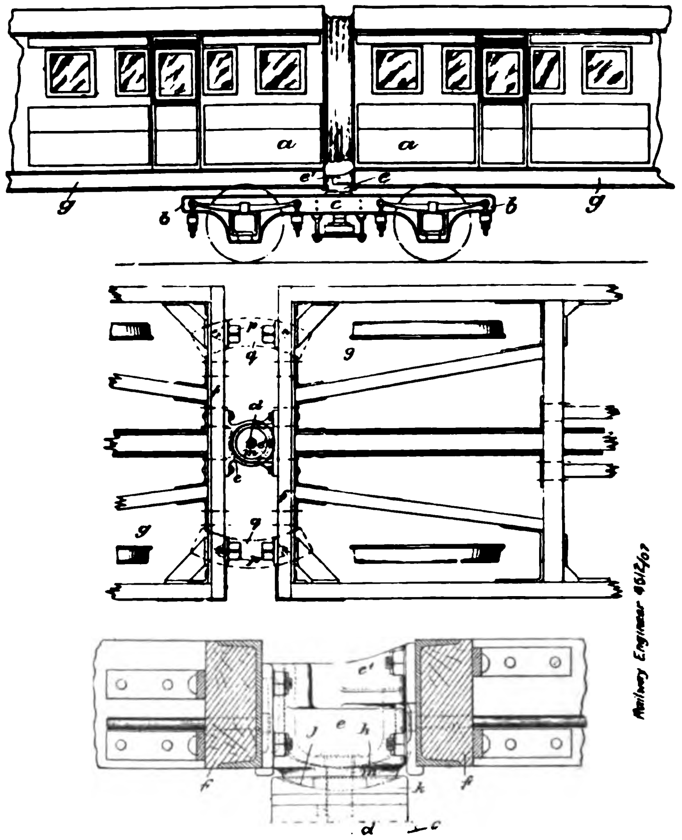
THESE abridgements of recently published specifications are specially compiled for this Review by Messrs. Wheatley and Mackenzie, Chartered Patent Agents, 40, Chancery Lane, W.C., from whom copies of the specifications can be obtained at an uniform price of 8*d*. each.

Carriage Windows. *10,623. 7th May, 1907. Date claimed under Patents and Designs Act 1907, 19th November, 1906. A. E. Ostrander, 688, East 25th Street, Paterson, Passaic County, New Jersey, U.S.A.*
Metal window frames of various shapes are provided with integral flanges arranged on the outside of the wall of the carriage, and with similar flanges on their inner sides to which the sashes are secured. A vertical post 4 is arranged between the windows 2, 2, and extends behind the semi-elliptical window 3, up to the side plate angle 5, to which it is connected, as shown in fig. 3. This post, as shown in fig. 2, is a built-up structure consisting of a T, to which wooden fillers 6 are secured, the outside of the post being covered by a metal casing 7. Stop strips 8 and pressed metal window stops 9 are secured to these fillers, and between these stops and stop strips the sashes of the twin windows are arranged.



The sash 10 of the semi-elliptical window is connected to a finishing batten or window frame 11, that is fastened to the sub-letter-board forming part of the side wall. This frame 11 may be either a pressed metal member or a casting, and is provided with a flange 12 arranged on the outside of the wall and connected thereto by fastening devices 13, the frame also being provided at its inner edge with a flange 14, through which fastening devices 15 extend to secure the sash of the semi-elliptical window in position. The oval window 1 is set in a frame 16, provided with a flange 17, which is arranged on the outside of the wall, and fastening devices 18 pass through the flange to connect the frame to the side wall of the car. The frame is also provided with an inwardly extending flange 19, against which the sash of the window 1 rests, and fastening devices 20 extend through this flange and sash to retain the sash in position This frame 16 also may be either cast or formed from pressed metal. *(Accepted 16th January, 1908.)*

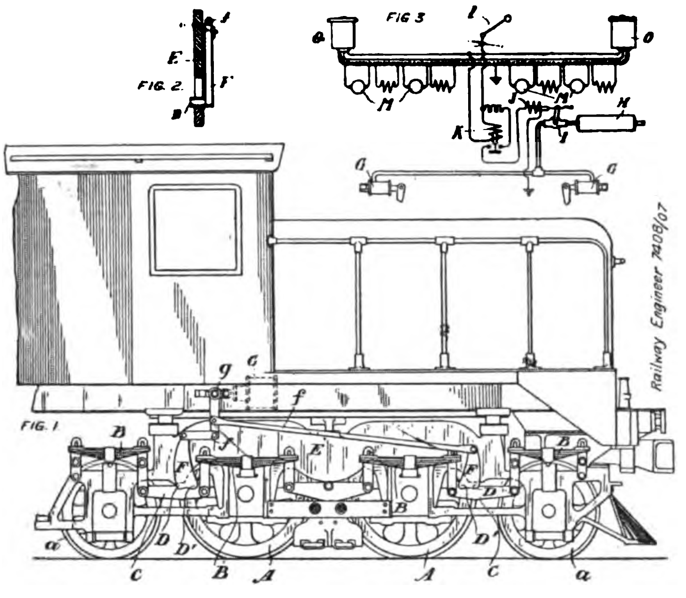
Twin Carriages. *4,512. 23rd February, 1907. H. N. Gresley, Milford, Doncaster, York.*
According to this invention the adjacent ends *a* of two carriages are supported on one common bogie truck *b* through brackets *e* e^1 fixed to the vehicle ends, and adapted to so engage one with the other as to serve as a coupling or connection between the vehicles. The bracket *e* is formed as a cup with a concave inner face *h* and a convex base or under surface *j* which bears directly or through an interposed thin metal washer on the corresponding concave face of the bogie centre casting or swivel plate *k* of the bolster *c*. The bracket e^1 has a hollow head adapted to fit within the cup of the



bracket *e* and is formed with a convex under surface that then works on the concave inner surface *h*. A king bolt or pivot *d* extends through centrally arranged clearance holes *m* in the head and cup and between the head and cup sufficient space is left for the head to rock freely to a limited extent, the arrangement being such that the brackets can turn horizontally and vertically relatively to each other and to the bogie centre casting or swivel plate *k*. Brackets *p* fixed to the vehicle headstocks *f* are adapted to work upon side bearing plates of the bogie *b*. *(Accepted 2nd January, 1908.)*

Electric Locomotive. *7,408. 27th March, 1907. The British Thomson-Houston Co., Ltd., 83, Cannon Street, London, E.C. A communication from the General Electric Co., Schenectady, New York, U.S.A.*
The weight on the driving wheels is, according to this invention, varied in accordance with the load on the motors, by placing an electro-magnet in the motor circuit which responds to an increase of current in the circuit above a predetermined amount, and controls a device which shifts the load automatically. The locomotive frame E rests on pins D, D, supported on equalising links C suspended from the springs B, B. Levers F F carry the pins D and other pins D^1 arranged nearer the axle of the driving wheel, and are connected through links *f* with the piston of an air cylinder G adapted to operate the levers to shift the load from the pins D to the pins D^1, thereby shifting the effective points of support on the equaliser links toward the driving wheels to increase the proportionate weights carried by those wheels. A valve I controlling the admission of air to the cylinder G from a main reservoir H is controlled by a magnet J, which in turn is controlled by an overload magnet K placed in the circuit with the driving motor M. This magnet is shown inserted between

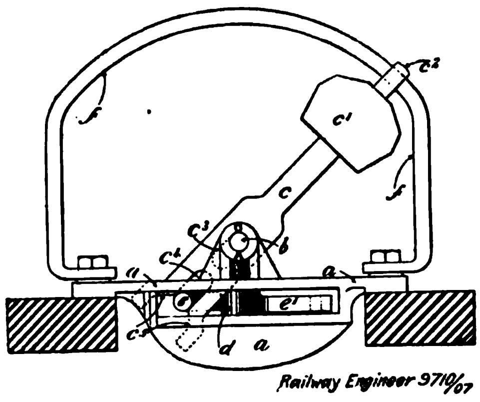
the trolley or current collecting device L, and the switches O, shown diagrammatically which control the supply of current to the motors M. Whenever either switch O is moved to close the motor circuit, current passes through the magnet K, and if the current admitted to the motors rises above a certain limit, magnet K draws up its armature, thereby energising magnet J and shifting valve I to admit air from the



reservoir H to the cylinders G. Thus, at starting, when the maximum traction effort is required, the magnet K will be energised, since the starting current is large, and in general whenever current above a predetermined amount is admitted to the motors, so as to increase their torque above a certain amount, the magnet K will be energised sufficiently to close its contacts, and the proportionate load on their drivers will be increased. *(Accepted 9th January, 1908.)*

Ground Switch Levers. *9,710. 26th April, 1907. L. W. Williams, O. R. Williams, and D. D. Williams, Railway Appliances Works, Cathcart, Renfrew.*

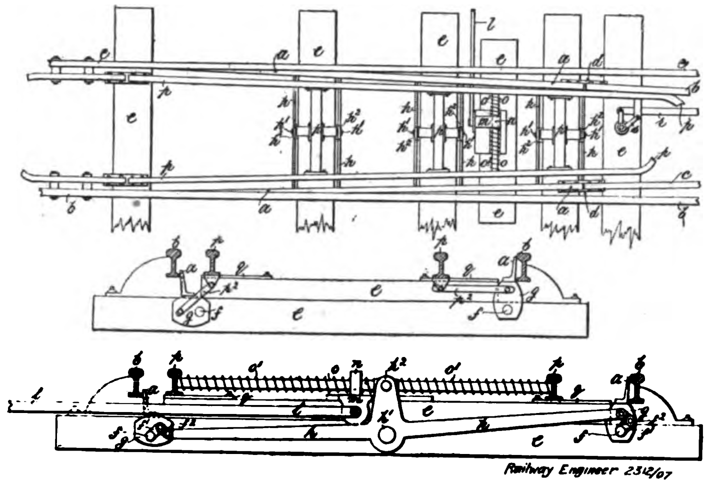
The switch lever consists of a weighted slotted lever c oscillating on a horizontal fulcrum pin b, and a crank e e^1 mounted on a vertical fulcrum pin d, one arm e of the crank engaging in a slot c^4 in the lower end of the lever c, and the other e^1 being connected to the switch rod. Should the switches be



trailed when the lever is in the position shown, the lever will be swung over to suit the direction of the trailing vehicles. When the shunter has to move the switches, the handle c is first pulled out so that the fulcrum pin b is at the lower end of the closed slot c^3. In this position the arm e of the crank e, e^1, does not engage in the lower slot c^4, but engages in the "Y" shaped end c^5, where there is sufficient clearance, provided that the weight c^1 can be raised to, or approximately near the vertical position before starting to move the switches, the object being that the shunter shall not at the same time have to raise the weight c^1 and move the switches. When the weight c^1 has been raised to the central position or slightly past, the "Y" end of the handle c comes into operation and oscillates the crank e, e^1, moving the connecting rod into the other position, thereby reversing the switches. *(Accepted 9th January, 1908.)*

Facing Point Switches. *2,312. 30th January, 1907. W. H. Taylor, 3, Brown Street, Market Street, Manchester. A communication from G. Harding, Heideberg Station, Transvaal.*

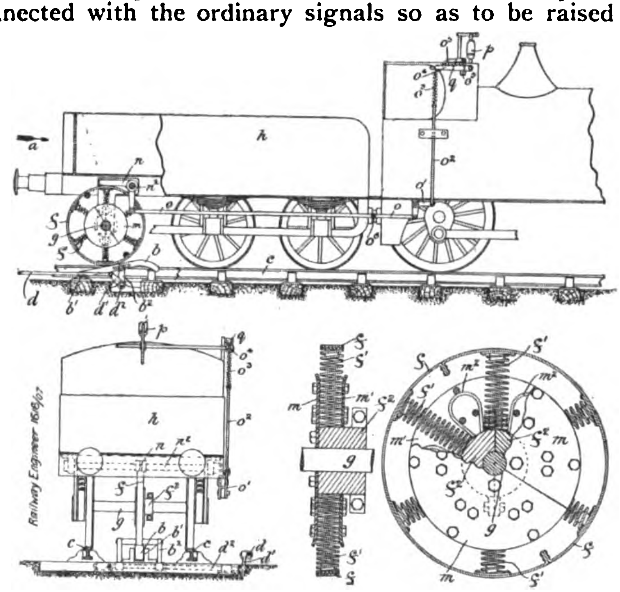
The points a are adapted to be raised alongside the rails b into a position level with the rails or lowered into a position entirely out of the way of the wheel flanges, by means of cams g, mounted on shafts f, and operated through rocking levers h, in such manner that when one point is in the raised position the other is in the lowered position. The operating



rod l is connected to a slide m having a projecting boss n adapted to freely embrace a rod o forming part of a frame p arranged to be laterally slidable upon beds q carried by the sleepers. The rod o is surrounded by a pair of springs o^1 one of which bears against one side of the boss n and one of the longitudinal rails of the frame whilst the other bears against the opposite side of the boss n and the other longitudinal member of the frame. When the operating lever is pulled from right to left the frame p moves from left to right. In doing so studs carried by the frame engage with the upwardly-projecting arms h^2 of the rocking levers h and cause the facing points to be raised and lowered. In fig. 2 the frame p is shown connected directly to the cams by short links p^2. *(Accepted 16th January, 1908.)*

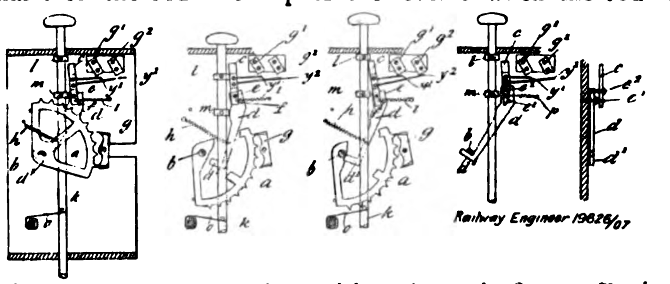
Signalling Apparatus. *1,616. 22nd January, 1907. J. H. Buckley, 181, Worsley Road, Little Hulton, near Farnworth.*

A lever or ramp b mounted between the rails and operatively connected with the ordinary signals so as to be raised and



lowered therewith, is arranged to actuate signalling mechanism on the engine or train through a spring wheel or spring rim *f* mounted on an axle on the tender or guard's van. On coming in contact with the ramp *b* the wheel *f* is deflected and operates a signal such as a whistle *p* through suitable connections. *(Accepted 16th January, 1908.)*

Electrical Signal Lock. *19,626. 2nd September, 1907. Siemens Bros. and Co., Ltd., 12, Queen Ann's Gate, Westminster. A communication from Siemens and Halske Actiengesellschaft, 3, Askanischer Platz, Berlin.*
This invention relates to electrical locking apparatus for signalling mechanism of the kind described in Specification No. 2,923, of 1872, in which a rod having been pressed a scape segment is operated by an anchor which, being the polarised armature of an electromagnet, is oscillated by a series of alternating currents. In order to prevent the rod being pressed down a second time before the parts have been returned to normal position the present invention provides a system of levers directly influenced by the rod and the spindle of the scape segment. The system of levers comprises two levers *c*, *d*, each turning on the fixed pin *e*. In normal position the lever *c* is drawn by spring *i* against a stop *f* carried by the lever *d*. A second spring *h* keeps the lever *d* with its nose d^1 engaged with the flat surface of the spindle *b* of the scape segment *a* which spindle is of semi-circular cross section. In this position of the parts the segment is locked and the collar *l* on the rod *k* can pass the lever *c* when the rod is



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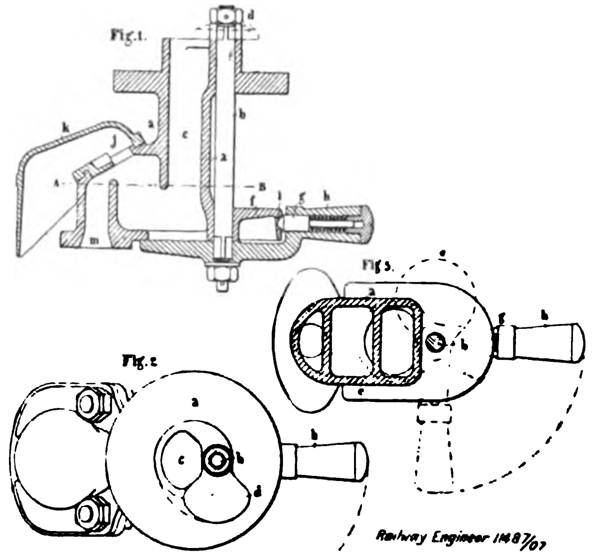
pushed down to assume the position shown in fig. 2. During this movement a second collar *m* on the rod pushes aside the lever *d* so that the pin *f* recedes from the lever *c*, which, however, cannot follow the pin being prevented by contact with collar *l*. When now the scape segment is brought into the position shown in figs. 2 and 3 and the pressure is removed from the rod so that it is lifted by spring *o* into its normal position, the nose d^1 of the lever *d* bears against the curved surface of spindle *b* and the lever cannot return to normal position. Thus the lever *c* is drawn by its spring *i* until it takes under the collar *l*, in which position it prevents the rod *k* from being depressed. When the escapement is returned to normal position, the flat surface of spindle *b* allows lever *d* to return and by engagement of its pin *f* with lever *c* to bring the latter back into its original position, thus unlocking the rod *k*. In order that spring *h* may not have to overcome the tension of spring *i*, the latter may be attached to lever *d* instead of to the framing of the apparatus. By modifying the apparatus as shown in figs. 4 and 5 a single spring may suffice. The lever *d* turns on a pin e^1 carried by the framing while lever *c* turns on a pin e^2 carried by the lever *d* and the spring *p* is attached at one end to the lever *c* at a point between e^1 and e^2 and at the other end to the framing; thus the spring tends to turn the lever *d* in a clockwise direction and lever *c* in the opposite direction. The pin e^1 acts as the stop for the lever *c*. *(Accepted 23rd January, 1908.)*

Sanding Appliance. *11,487. 16th May, 1907. H. E. Gresham, Craven Iron Works, Salford, Lancaster.*
The sand trap *a* intended for use on locomotives, has a rotatable spindle *b* mounted longitudinally and parallel with the aperture or passage *c* which extends through the body *a*. At its upper end the spindle *b* carries a valve plate or shutter *d* adapted to close the upper end of the throughway passage *c*. At its lower end there is fixed to the spindle *b* a handle plate *e* adapted to close the lower end of the throughway aperature *c*, and to serve for the rotation or semi-rotation of the spindle *b* whereby the valve opening and closing movements are effected. The lower portion *f* of the body part *a* of the trap is extended laterally to form a weather guard to cause the rain or moisture trickling down the trap to drip clear of the same; the edge of the guard or shield *f*, or a portion of it, is made to a semi-circular form and serves as the path for the nose of a spring controlled position peg *g* fitted in the grip or handle end *h* of the handle plate *e*. In the normal working condition of the apparatus the lower end of the throughway aperture *c* in the sand trap is closed by the handle plate *e*,



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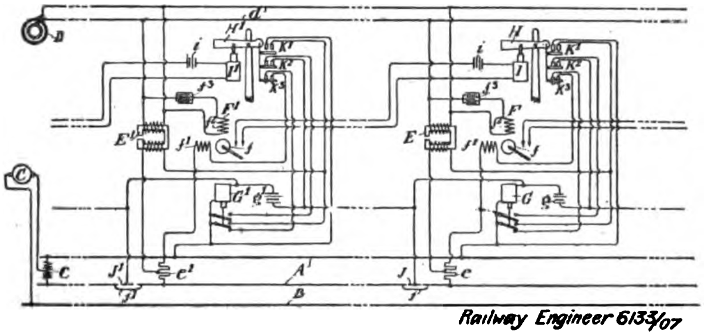
whilst the upper end of the aperture is open as the valve *d* at the upper end of the spindle *b* is then turned away from or clear of the aperture *c*. The spindle *b* and its respective valves *d*, *e*, or their equivalent, are prevented from accidental movement from their normal positions by the engagement of the position peg *g* with a notch or groove *i* in the semi-circular edge of the weather guard or rain shield *f*. But should an obstruction occur in the sand trap, access can be readily obtained thereto by moving the grip or handle plate *e* at the lower end of the spindle *b*, against the action of the spring position peg *g*, thereby opening the lower end of the throughway aperture *c* of the trap and simultaneously closing the upper end to shut out the sand from the sand box. After the removal of the obstruction, a return movement of the spindle *b* restores the parts to their normal position so that the working of the apparatus may be resumed. *(Accepted 30th January, 1908.)*

Block Signal System. *6,133. 13th March, 1907. The British Thomson-Houston, Co., Ltd., 83, Cannon Street, London, E.C. (a communication from the General Electric Company, Schenectady, U.S.A.).*
This invention relates to a block signal system for electric railways in which both rails are electrically continuous and serve as the return circuit for the power current and also as the circuit for alternating signal currents. Transformers E, E^1, with normally open contacts, are connected at intervals across the rails, the contacts being closed by the energising of electro-magnets G, G^1, on the approach of a train or vehicle. Normally all the circuits are open and no current is flowing in any of them. When a train reaches an insulated section J, the axles of the train circuit connect the section to the opposite rail, thereby completing a circuit from the upper terminal of a battery *g* through the magnet G^1, the upper rail A, the train-axles, and insulated section J to the lower terminal of the battery. The magnet G^1 consequently is momentarily energised and draws up its armature. Assuming that the right hand magnet G has been thus energised by a train approaching from the right when it draws up its armatures a maintaining circuit for itself is closed from the upper terminal of battery *g* though the magnet winding G and through the upper armature, and the contact k^2 controlled by the signal H to the lower terminal of battery *g*.

Consequently, the magnet G does not drop its armatures when the train passes from the insulated section, but holds them closed. The raising of the lower armature serves first to break the circuit of the track winding f^1 of relay F, and then to close the circuit of the transformer E. The purpose of closing the transformer circuit is to energise the relay F^1 for the block which the train is about to enter, while the opening of the track winding of relay F is to prevent its acting as a short-circuit for the transformer winding. When the transformer E is thus connected to the track, it supplies to the track-rails a current which energies the winding f^1 of the relay F^1, if no rails are broken between the transformer and relay, and no train is in the section between, so as to short-circuit the relay. This circuit may be traced from the left hand terminal of the secondary of transformer E, through resistence e, lower rail A, resistance e^1, winding f^1 of relay F^1, contact k^3 of signal H^1, back contact and lower armature of magnet G^1, upper rail A, lower armature and front contact of magnet G, to right hand secondary terminal. When the relay track winding is thus energised, a torque is produced on the secondary member f so that the relay contacts are closed, thereby energising the operating mechanism I of the signal H, which is consequently drawn to clear position to



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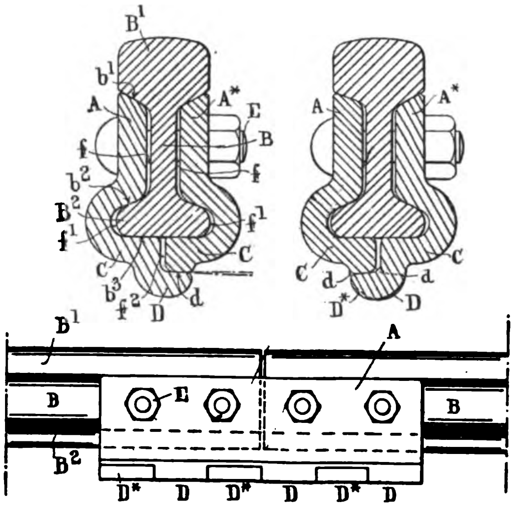
indicate to the approaching train that the block is clear. It will be seen that the transformer is at the entrance-end of the block and the relay at the exit end. There are two reasons for this arrangement, first, the circuits of the magnet G and its armatures are made shorter and simpler, and second, the point of which the relay F^1 is short-circuited by an approaching train is made more definite. When the signal H clears, it first closes a second circuit for the transformer E through the contact k^1 and then breaks the circuit of track winding f^1 of relay F at contact k^3 and the maintaining circuit of magnet G at contact k^2. Magnet G is consequently de-energised and drops its armatures, but the circuit of the transformer E is still closed and the circuit of relay winding f^1 is still open at the contacts of the signal. These conditions are maintained and the signal remains at clear position until the train approaches so close to the transformer as to pull down the voltage supplied to the track an amount sufficient to cause the left hand relay F to drop its armature. This will occur when the train reaches a point a certain distance from transformer E determined by the frequency of the transformer current, the regulation of the transformer, and the design of relay F^1. By employing a high frequency for the signal currents, to which the rails offer a high impedance, and by properly designing the transformer and the relay this distance may be made one hundred feet, or even less. One reason for placing the transformer at the entrance end of the block is to make this distance determinate. If the relay were placed at the entrance end of the block, the distance at which the train would shunt the relay would be greater, and consequently more liable to variation. When the signal goes to danger, due to the near approach of the train to the transformer E, the contacts controlled by the signal break the transformer circuit and close the circuit of winding f^1 of relay F, thereby restoring all the circuits to their original condition, with no current flowing in any of them; thus it will be seen that no current at all is employed in any of the signal circuits as long as no train is running, and for each train a certain amount of current is employed while the train is running from an insulated section J to the succeeding transformer. (*Accepted, 9th January, 1908.*)

Fish Plates. 5,540. - *7th March, 1907. G. Estall, 45, West Cromwell Road, Kensington, London, S.W.* The fish plates are formed with downward extensions C, which are curved around the bottom flange B^2 of the rail so as to make close contact with its under surface b^3, one of the plates of a pair being provided with a further and somewhat similar extension D adapted to take under and support as at d the bottom of the other plate of the pair. The arrangement is such that as the plates A, A* are drawn towards one another and towards the sides of the rail by the tightening of the fish bolts E, the primary extensions C on each plate will maintain close contact with the under side b^3 of the bottom flange B^2 of the rail so as to support the latter and assist directly in counteracting the tendency of the rail joint to bend downwards, whilst the upper surface of the secondary



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extension D on the one plate A will at the same time maintain close contact with the bottom of the other plate A* and thus assisting in preventing flexure of the rail joint by counteracting the tendency of the latter fish plate to bend vertically. In order to ensure this result, the mutally contacting surfaces of the two plates, as indicated at d, are made not parallel to the direction in which the plates move when drawn towards one another, in other words are not made transversely horizontal, but are made with a slight transverse inclination such that the mutual approach of the plates will, in consequence of the wedging action produced, cause the primary extension C of the plate A* to tend to ride upwards upon the secondary extension D of the plate A, with the result that the primary extension will the more forcibly contact with the bottom surface b^3 of the bottom flange B^2 of the rail. (*Accepted, 2nd January, 1908.*)

COMPLETE SPECIFICATIONS ACCEPTED.

1907.

759. Brakes for tramway cars. Howard.
813. Automatic fog-signalling apparatus for railways and the like. Davies.
837. Means for controlling the locking of railway carriages and the like. Ratcliffe.
1616. Railway signalling apparatus. Buckley.
2312. Facing point switches for railways and tramways. Taylor.
2413. Electrical block signalling system for railways. Brown.
2686. Buffers for railway wagons or like vehicles. Rigley.
3604. Form of coupling for railway wagons and other vehicles. Jackson.
3775. Couplings for railway vehicles. Marks.
4092. Railway train speed-recording apparatus. Shortt.
4158. Apparatus for operating and controlling railway points and signals. Menard.
4274. Interlocking apparatus for railways and tramways. Edmonds, and McKenzie and Holland, Ltd.
4512. Railway and tramway vehicles. Gresley.
5540. Railway fish plates. Estall.
6133. Signalling systems for railways and the like. British Thomson-Houston Co.
6398. Spring locks for railway-carriage, brougham and other doors. Galley, Hunt and Du Puy.

is normally held closed by an electro-magnet in a local circuit on the engine. The "all right" and "danger" indications are also operated by electro-magnets. The whistle electro-magnet has a resistance of 1,000 ohms, the electro-magnet operating the "danger" indication 100 ohms, and the electro-magnet operating the "all right" indication 10 ohms. A common battery on the engine supplies current for all three electro-magnets, the operation of which is as follows:—The whistle electro-magnet (1,000 ohms) is in series with the "danger" signal electro-magnet (100 ohms) and current normally flows through these two electro-magnets. This current is sufficient to keep the whistle electro-magnet closed, but on account of the high resistance of this electro-magnet there is not sufficient current to operate the "danger" indicator. At each signalling position a steel bar, called a "Crocodile," is provided, which, when the line is clear, is connected at the signalling position, by means of a switch operated by the wire working the semaphore signal, to the running rail. When the line is not clear the steel bar is electrically disconnected from the running rails. Two brushes are provided on the engine in connection with the circuit of the whistle and "danger" electro-magnets, so arranged that when the train reaches a signalling position these brushes make contact with the steel bar, and short circuit the whistle electro-magnet, which being de-energised admits of the whistle sounding. At the same time, owing to the short circuiting of the resistance of the whistle electro-magnet, sufficient current passes through the "danger" electro-magnet to admit of its operating the indicator needle so as to show "danger." If the line is clear and the steel bar is connected with the running rails, in addition to the whistle electro-magnet being short circuited, the "all right" electro-magnet (one end of which is connected to the mass of the engine and the other end to one end of the common battery on the engine), is owing to the steel bar being put in electrical connection with the running rails put in parallel circuit or shunt with the "danger" electro-magnet, and on account of the lower resistance of the "all right" electro-magnet this causes the needle of the indicator to show "clear."

(To be continued.)

Official Reports on Recent Accidents.

Near **Goswick, N.E.R.** *On the 28th August. Lieut.-Col. P. G. von Donop, R.E., reports that:—*

The 11.22 p.m. up goods train (6 coupled bogie engine, tender and 20 vehicles) from Tweedmouth was derailed. The driver and fireman were killed. The engine turned right over into a ditch, 9 of the vehicles were completely destroyed, and 8 were much damaged. The guard in the rear van was so injured that he was unable to give evidence for three months.

The engine and tender were fitted with the Westinghouse automatic brake and also with the vacuum automatic brake apparatus, with which 17 of the vehicles of the train were fitted.

The train was a braked goods train, *i.e.*, a goods train all the vehicles of which were either fitted with the vacuum automatic brake or piped; it was authorised to run at a speed of 55 miles an hour.

Goswick Station is 5 miles on the up side of Tweedmouth on the N.-E. main line. The lines lie approximately north and south, the up line being on the east side. The Goswick Station up platform is 300ft. in length, and immediately adjoining the south end of it there is a public road level crossing; the station signal-box is situated on the up side of the line immediately to the south of the level crossing. At a point on the up main line, situated 260ft. to the south of the signal-box, there are the facing points of a connection leading to an up independent line, which commences at this spot and terminates at the next station. viz., Beal, a distance of 3,390 yards. This up independent line lies on the east side of the up main line and there is a space of 6ft. between the two lines. The derailment of the train occurred on the up independent line, a short distance ahead of the trailing points of the connection.

The up lines are provided with the following signals:—

A distant signal for the up main line and a distant signal for the up independent line, both signals being situated at a distance of 1,065 yards to the north of the signal-box.

The "intermediate" main up signal 260 yards and the "main up" signal, 15 yards north of the signal-box.

An up main line starting signal and an up independent starting signal situated alongside each other, 80 yards to the south of the signal-box.

The driver of an up train approaching Goswick obtains a very good view of all his signals, and he sights the distant signals when about 1,400 yards from the signal-box.

The next station north of Goswick is Scremerston, distant 2 miles 67 chains.

The night is said to have been a very clear one.

The connection at Goswick leading from the up main line to the up independent is of the usual description, 160ft. long and consists of a reverse curve, each portion of which is of 10 chains radius; there is practically no straight portion between the two curves, and no super-elevation is given to the outer rail in either case. It is clearly only suited for trains to run through at a low rate of speed.

Regulation No. 148: "Engine-drivers of trains, when running through junctions to or from lines diverging from the straight road, must so reduce their speed as to ensure a steady passage for the whole train through the junction points and crossings."

The 11.10 p.m. up goods arrived at Goswick at 12.24 a.m., and it ran through that station on the up independent line. Driver Bennett, in accordance with Regulation No. 148, reduced his speed, ran through that connection at a speed of about 5 miles an hour, and arrived at 12.29 a.m. at Beal, where it was brought to a stop by signal on the up independent line. The reason for running this train on the up independent line and for stopping it at Beal was in order to keep the up main line clear for the 10.55 p.m. express from Edinburgh to London, and which passed through Goswick Station on the up main line at 12.28 a.m., and through Beal on the same line at 12.31 a.m., at which time the 11.10 p.m. goods train was still standing there on the up independent line.

At 12.28 a.m. when signalman Hay, who was on duty in the Goswick box, had sent the train-out-of-section signal for the 10.55 p.m. express train to the signalman at Scremerston, the latter offered the former the 11.22 p.m. up goods train. Signalman Hay accepted this goods train forthwith, keeping, however, all his signals at danger, and at 12.31 a.m., when he received the train-out-of-section signal for the 10.55 p.m. express train from signalman Brown, who was on duty in the Beal box, Hay offered Brown the 11.22 p.m. goods train. Brown did not accept the train, but he asked Hay on the telephone to keep all his signals at danger until he (Brown) had ascertained the whereabouts of the 11.15 p.m. up express train from Edinburgh to Newcastle. Hay accordingly kept all his signals at danger, but at 12.32 a.m. he received a signal from the signalman at Scremerston to shunt the goods train for the express to pass, and about the same time he saw that the 11.15 p.m. up express train was reported as starting from Berwick. Hay accordingly called up Brown again on the telephone and informed him that he had received the shunt signal from Scremerston, on which Brown instructed him to put the goods train into the up independent line. Hay states that at this time the goods train was approaching the distant signal, so he forthwith altered the junction points, setting the road for the up independent in lieu of the up main; he still kept all his signals at danger, but when the train was close to the intermediate main up signal he lowered that signal in order to allow the driver of the train to draw up to the main up signal.

If, as signalman Hay asserts positively, the distant signal was at danger, driver Brown, who was in charge of the engine of the train, would, when upwards of 1,400 yards from the signal-box, have received the warning signal that he might expect to find some of the station stop signals at danger. The intermediate main up signal was undoubtedly lowered as Brown approached it, but even before reaching this signal he obtained an excellent view of both the main up signal and the two starting signals, all of which Hay asserts to have also been at danger. Brown, however, failed to bring his train to a stand at these signals, and he ran past them at express speed.

When the engine was examined after the accident it was found that the driver's vacuum brake handle was in the "running" position, indicating that the brakes had not not been applied to the train; the driver's Westinghouse brake handle had unfortunately been removed soon after the accident, when searching for the bodies of the driver and fireman, and its position was not noted before its removal. No great reliance can, however, be placed on the conclusions drawn from the positions of any of the handles on the engine, as their positions may undoubtedly have been due to blows received at the time of the derailment.

From the evidence it appears to be certain that the braking arrangements of the train were all in good working order when it started from Tweedmouth; it is very unlikely therefore that both the vacuum and the Westinghouse brakes should have become defective before reaching Goswick, and, as far as the evidence goes, it certainly points to the brakes not having been applied before the accident occurred.

It must, however, be pointed out that had there been any defect in the engine, owing to which driver Brown was unable to turn off steam, or had there been any failure of the automatic brakes, the fact should have been discovered by him at all events when he sighted the distant signal, at which time he would have been about 1,400 yards from the signal-box. Under those circumstances Brown should have, by means of his whistle, made known the fact that he had lost control of his engine. According to the evidence, however, Brown only whistled when passing through Goswick Station, and it was only natural that he should do so at that point, as in addition to the station there is a public road level-crossing over which he was running. From the fact of his having made no use of his whistle before reaching the station it

seems therefore to be very improbable that driver Brown had lost control of his engine.

The evidence and facts appear therefore to point to the conclusion that the station signals were at danger, as stated by signalman Hay, and that the failure of driver Brown to act on the instructions thereby given to him was not due to any defect in the engine or to any failure of the brakes of the train.

Brown was a driver of considerable experience; he was 55 years of age, and had been 41 years in the N.-E. service; he had been promoted driver in 1889. Mr. Alfred Rymer, district locomotive superintendent at Tweedmouth, and under whom Brown had been working for 3 years, gives him an excellent character, and he does not appear to have been addicted to drink. In the history of his services there are three entries against him of having over-run signals, one entry of over-running a platform, and two entries of omitting to stop at stations where he was due to do so. The last of these offences occurred in 1901.

Fireman Nicholson, who was on the engine with driver Brown, is also given a very good character, and there are no entries of any sort against him in his history of services. He was a teetotaler.

Foreman Smith, who saw both Brown and Nicholson before they started from Tweedmouth on this journey, states that they were both perfectly sober and thoroughly fit for their work. Both had been on duty for 10½ hours on the previous night, and signed off duty at 8.30 a.m. on the 27th; they had then come on duty again at 10.15 p.m., and they had been 2¼ hours on duty when the accident occurred.

Attention must be called to a somewhat strange piece of evidence given by brake examiner Athay. He states that, after having seen the brakes of the train duly tested at Tweedmouth on the night of the accident, he went on to the engine and had some conversation with driver Brown with reference to driver Bennett, who was in charge of the engine of the 11.10 p.m. goods train which was preceding the 11.22 p.m. train. Athay states that he himself remarked that driver Bennett's train would be put into the independent line at Goswick, and that driver Brown would have a chance of passing him: Brown replied that he would have a chance of doing so. Fireman Nicholson remarked that he had been on the same job once or twice before, and that he had never seen it done, on which driver Brown remarked that he had seen it done twice or thrice, and that he would have a chance of getting into Newcastle before driver Bennett if the express train was not too close on him. Athay states that it was he himself who started this conversation. From the above conversation it is clear that driver Brown had an idea in his mind that the 11.10 p.m. goods train would be put into the up independent line at Goswick in order to clear the up main line for the 10.55 p.m. express train; and that, consequently, if only he could keep well ahead of the 11.15 p.m. express train, there was a chance of his own train being allowed to run through on the up main line whilst the 11.10 p.m. train was still detained in the up independent. One would think that the fact of Brown having this possibility in his mind would have been a special incentive to him for keeping a sharp look out for the positions of the Goswick signals, and, from that point of view, it seems therefore to make it the more unlikely that he should have failed to observe the positions of these signals when he was approaching them. On the other hand, it is possible that Brown had got such a strong conviction that he would be allowed to run through on the main line that the necessity for looking for his signals escaped him. This will certainly account for the speed at which he was running, and it may also possibly be the explanation of his omission to observe his signals; there seems no doubt whatever that driver Brown did omit to do so, and that it was to this omission that the accident was due.

There are three points which call for notice.

(1) It appears from Hay's evidence that, when he accepted the 11.22 p.m. up goods train from the signalman at Scremerston, the junction points ahead of his signal-box were lying set for the up main line. Regulation No. 4, for block working on double lines of railway, states that, after permission has been given for a train to approach, no obstruction of the line must be allowed until the train has been brought to a stand at the home signal. Hay states, however, that he altered those points, setting the road for the up independent after he had accepted the goods train, and at the time that that train was approaching his distant signal. Hay states that his intention was to stop the train at the signal-box, so there does not appear to have been any necessity for his having shifted the points until the goods train had been brought actually to a stand. As a matter of fact, if Hay had strictly adhered to the rule, the derailment would not have occurred as, though it would not in any way have prevented driver Brown running past his signals, his train would not have run through the connection leading to the up independent.

(2) The Company's Regulation No. 40 is to the following effect: "When the starting signal is at danger the home signal must not be lowered for the approaching train until the train is close to the home signal and has been been brought quite or nearly to a stand at it." In the description given above of the up signals at Goswick it will be noted that there is no signal called the up home signal. The signal known as the intermediate main up signal, which is the one which would be put to danger for the protection of a train stopping at the up Goswick platform, certainly appears to be the one which should be called the up home signal, and to which the Rule quoted above should refer. It is clear, however, that Hay did not regard that signal as being his home signal, for he states in his evidence that he lowered his intermediate home signal in order to allow the driver to stop at his home signal, so that he could caution him into the independent. From this it is clear that Hay regarded what is known as the main up signal as his home signal. He consequently did not consider that it was necessary for him to defer lowering the intermediate main up signal until the train had come nearly to a stand, and it is quite evident from what occurred that the train was going at a very high rate of speed at the time that that signal was lowered. The nomenclature of the signals is confusing, and under these circumstances Hay cannot be blamed for his action in the matter. The Company should alter the names of these signals so as to bring them more into unison with their Regulations.

(3) The two goods trains concerned in it were due to leave Tweedmouth at 11.10 p.m. and 11.22 p.m. respectively, whilst the two express passenger trains also concerned in it were not due to arrive there till 12.18 a.m. and 12.32 a.m. respectively. Had the goods trains therefore started punctually to time they would both have been about an hour in front of the express passenger trains, and they would both have been able to run through on the up main line without any shunting or delay, and this accident would not have occurred. But the fact of both the goods trains starting about an hour late placed them immediately in front of the express trains and entailed the delay and shunting between Goswick and Beal which resulted in this accident. This may therefore be regarded as one of the numerous accidents which would not have occurred if punctuality had been observed.

*

Birmingham Corporation Tramways. *On October 1st. Col. H. A. Yorke, reports that:—*

Car No. 22 ran away down Warstone Lane and overturned at the corner of Icknield Street, striking an overhead standard as it fell. Two passengers were killed and 12 were injured.

The car was of the 4-wheeled, double-decked type, fitted with a hand brake, an electric rheostatic brake, and a magnetic track brake, 4 sanders, and a lifeguard of the trigger type. Its total length was 27ft. 6ins., the wheel-base being 6ft. The gauge is 3ft. 6ins.

There were about 16 passengers, half of whom were on the top.

Warstone Lane is about ¼ mile long, the gradients being from the top: 1 in 143·8, 1 in 22·7, 1 in 17, 1 in 19·7, and 1 in 36·6. It is straight, but at the bottom the curve has a radius of 40ft. to the right. The superelevation of the outer rail at the centre of the curve is 1⅞ins. The regulations provide that all cars shall stop at both the top and bottom of the hill, and that the speed round the curves shall not exceed 4 miles an hour.

The immediate cause of this accident was the action of Inspector Hall in taking the car down Warstone Lane with a defective magnetic track brake, and experimenting with that brake on the incline. Had he applied the hand brake before starting down the incline no accident would have occurred, as the gradients are such that the car might well have been controlled by means of the hand brake only, the only precaution necessary being that the hand brake should be applied at the commencement of the hill, so that the speed of the car should be checked from the outset. That this is the case is proved by the fact that motorman Mountford had already taken the car down the hill that morning by means of the hand brake only. Inspector Hall seems, however, to have selected this hill for the purpose of testing the magnetic brake, and did not attempt to apply the hand brake until the speed of the car was far beyond its control.

In drawing the attention of Inspector Hall to the defect in the magnetic brake, motorman Mountford seems to have complied with the rule, and the responsibility for the accident must rest upon Inspector Hall, whose action was entirely contrary to the spirit of the last sentence in the rule, which forbids *motormen* to run a car not under absolute control.

The failure of the magnetic track brake to act on this occasion is said to have been due to a broken "grid" in the fourth resistance box on the car. According to a statement made by Mr. C. W. Hill, electrical engineer of the Corporation Tramways, the controller at "No. 2" end of the car, and the insulation of the cabling and wiring of the car, was after the accident found to be in good order, and the only defect that could be discovered was the broken grid. The resistance boxes, of which there are five, are in use both for propelling and braking purposes, and it might be thought that such a fracture would be discoverable, not only when the magnetic brake was in use, but also when current was being supplied from the trolley wire for the purpose of starting the car. Mr. Hill's theory is that the electrical pressure of the current for driving purposes would be sufficiently great to bridge the gap formed by the fracture, whereas, in the initial stages of braking, current generated by the motors acting as generators would have a low pressure, and would not be able to overcome the interruption in the circuit. Experiments made by Mr. Trotter, the electrical adviser to the Board of Trade, hardly support this theory, as it was found that a current of 10 ampéres, which is probably less than the usual current passing when cars are starting from rest, is sufficient to cause fusing to take place between the two opposing ends of the fracture and between the sides of the broken and adjacent members of the grid. No such signs of fusing were, however, discernible in this case. It is therefore impossible to say whether the above explanation of the failure of the magnetic track brake be the correct one or not.

*

At **Widnes East Junction, Cheshire Lines.** *On the 23rd December. Lt.-Col. E. Druitt, R.E., reports that:—*

The 4.42 p.m. goods train (6-coupled engine, tender, 13 loaded and 2 empty wagons and 15-ton brake) from Huskisson to Guide Bridge was run into from behind by the 4.33 p.m. up passenger train from

Liverpool to Stockport. The driver and fireman of the goods train were injured. The 8 rear vehicles of the goods train were derailed, fouling the down road.

The main lines between Liverpool and Manchester run past Widnes East Junction approximately east and west (the up line to Manchester being on the north side of the down line), and are quite straight. The branch line from Widnes runs from the south-west and joins the main line on a gradual curve, the double junction being just opposite the signal-box, which is on the south side of the down line.

The home signal for the up main line is 139 yards west of the signal-box, and that for the up branch line a similar distance back on the left-hand side of that line.

The next signal-box in rear on the main line is Farnworth East signal-box, and is 1,078 yards west of Widnes East Junction. The up home signal for Farnworth East box is 46 yards west of that box, and the up distant signal for Widnes East Junction is underneath and on the same post as this home signal. Thus the distance between the up distant and home signals for Widnes East Junction box is 985 yards. The up distant signal for Farnworth East box is 932 yards behind the up home signal.

On the branch line the next box in rear is Widnes Junction South, 999 yards back from the East Junction box. The up home signal at the south box is 83 yards south of the box, and the up distant for Widnes East Junction is underneath it, and so is 943 yards back from the up home signal.

There is an up starting signal at the South box, 405 yards ahead of the box, but no inner distant signal for Widnes East Junction is provided underneath this starting signal.

This collision was due to reckless driving by D. Downey, of the goods train.

Harris (East Farnworth box) had previously offered the goods train to Widnes East Junction box, but it was not accepted, so he kept his up distant, home and starting signals at danger, and they were all in that position when the goods train passed them.

J. Castree, the guard of the goods train, states he could see the up distant signal for Farnworth East box at danger, and also the home signal for that box and the distant signal underneath it both at danger as his van passed them, and he also saw the fogman show a red hand-signal. He then put on his hand brake as hard as possible, but this, of course, had no effect on the train. He states the train ran pretty fast past Farnworth East box, and was slowing down on approaching Widnes East Junction, and was just coming to a stand when the passenger train ran into it from behind. He jumped from the van just before the collision and was unhurt.

The up line junction points were burst by the goods train, and that the up main home signal was at danger when Downey passed it.

As soon as the goods train had run past the home signal at Farnworth East box (and it also passed the up starting signal while at danger as well) signalman Harris at once sent the signal "Train running away on right line" to Widnes East Junction, and W. Hill, on duty there, having accepted the passenger train, and having the home and distant signals lowered for it off the branch line, and also a down mineral train approaching to run on the down branch line, at once threw all his signals to danger, and did all he could to stop the passenger train by sending his fogman to put detonators on the branch lines. Also, finding the goods train had run past the up main line home signal at danger, he did his best to get it to go right away by shouting to the driver, but it stopped about 95 yards beyond the junction.

Driver Vick, of the passenger train on the branch line, was running with all signals off for him, including the distant signal for Widnes East Junction, but had reduced speed to about 25 miles an hour on approaching the junction, and, finding the branch up home signal at danger, did his best to stop his train, but he could only reduce speed to about 10 miles an hour before he collided with the rear of the goods train.

After the collision, Downey, without waiting for any instructions, or seeing anybody, at once started away with four wagons which were still attached to his engine, passed the up starting signal at danger and went to the next station, Sankey, where he left the wagons, and then took his engine to Warrington. There is no doubt but that Downey was perfectly sober both before and after the collision. He is nearly 49 years of age, but has the appearance of a much older man. He had been on duty less than one hour, after a rest of 13 hours. He has a fairly good record as a driver.

At Widnes East Junction box there is not an inner up distant signal for Widnes East Junction underneath the up starting signal of the signal-box in rear on both the branch and main lines. Had there been one underneath the up starting signal for Widnes Junction South box on the branch line it would have been thrown to danger by the signalman at Widnes East Junction before the passenger train passed it (being only 455 yards away from the up home signal for the East Junction box), and the driver of the passenger train would have received a warning to bring his train under control, ready to stop if necessary at the up home signal. These inner distant signals should be provided as is usually done in similar cases.

*

At **Porth, T.V.R.** *On the 2nd December. Lt.-Col. E. Druitt, R.E., reports that:—*

After an up train of 53 empty coal wagons and 10-ton van had been assisted up the incline on the Ferndale branch line above Porth Station, a coupling broke, and the rear portion of the train ran back along the down line, and forced the banking engine into a passenger train standing in the bay road at the station; 24 passengers complained of injuries.

The three first passenger coaches were badly damaged; 12 of the empty wagons were derailed, and the engine slightly damaged.

Leaving Porth the up line of the Ferndale branch rises at 1 in 109 for 88 yds., 1 in 70 for 66 yds., 1 in 53 for 308 yds., 1 in 47 for 176 yds., 1 in 67 for 242 yds., and 1 in 72 for 273 yds.

The train of empty coal wagons from Cardiff to Maerdy ran through Porth Station on the up main line and up the Ferndale branch, coming to a stop at the Aber Rhondda signal-box starting signal at about 9.23 p.m., most of the train being on a gradient of 1 in 53, but the engine and leading wagon on a gradient of 1 in 47. It waited here about 10 minutes for a banking engine to come on behind to assist it up the steep gradient of 1 in 47 and 1 in 67 to the next signal-box viz., Ynishir House.

As soon as this engine arrived behind the train, and the usual signal had been given, signalman J. B. Davies, at Aber Rhondda signal-box, lowered his starting and advance starting signals for the train to proceed, which it did, and came to a stand at the Ynishir House box home signal.

As soon as the train stopped, driver John Davies, on the banking engine, whistled for the cross-over road to be set for him to return to Porth Station (to join his train standing in the bay road) on the down line. The engine was only just ahead of the points of the cross-over road when the train stopped, and as soon as the disc signal was set for the engine to return, it started, and the rear wagon and brake van, being on a steep gradient of 1 in 67, commenced to move back slowly, as they had been buffered up coming up the gradient by the banking engine in rear.

As soon as the strain came on the coupling of the second wagon from the engine, which was on the drawbar hook of the third, it immediately parted, and the rear 51 wagons and brake van commenced to run back through the cross-over road on to the down line, following the banking engine.

John Davies, the driver of the banking engine, did not realise that the train had broken loose until he had gone some distance back on the down line, but as soon as he discovered it he slowed down, and met the runaway brake and wagons, at a point about 400 yards from where they had commenced to run back, and about 280 yards from the standing carriages in the bay road at the station. He then put all his brakes hard on, dropping sand, and did his best to stop the wagons, but he only succeeded in reducing their speed from about 12 to 6 or 7 miles an hour before he was forced back on to the standing carriages. He states that he would have met the wagons with greater force, and tried to derail some, had he known there were so many, but being dark he could only see the lights on the guard's van moving back towards him.

H. Gibbon, the guard of the empty wagon train, applied his brakes as hard as possible, as soon as he found his van was moving back through the cross-over road on to the down line, and did his best to attract the attention of the banking engine by whistling, but failed.

Signalman J. B. Davies, in Aber Rhondda box, did not notice that the wagons were following back after the banking engine until they were opposite the signal-box, 200 yards or so below the point they started from, and the banking engine had gone too far beyond the box for him to get the driver's attention. He at once gave the "Train running away on right line" signal to Rhondda Fach signal-box, and J. Price, the signalman there, at once ran to set the road so as to turn the runaway wagons out on to the down line, from which a passenger train had just departed. The road was at the time set for the banking engine to go back on to its train in the bay line, and to change the road to lead to the down main line seven lever movements are necessary, and Price had only time to get the first five completed before the banking engine got on the lock-bar of the facing points where the diversion would have been made, so he could not unbolt them. These facing points are only 120 yards below the point where the banking engine met the runaway wagons. Price had no time to give any warning to the station staff to get the passengers out of the standing train.

The collision was entirely due to the unfortunate breaking of the coupling, and all the men concerned acted with promptitude and did their best to prevent an accident. Driver John Davies is highly to be commended for meeting the runaway wagons with his engine, and thereby reducing their speed. Had this not been done the results of the collision might have been disastrous, and lives lost, as the standing carriages were well filled with passengers.

The wagon of which the coupling broke was an ordinary 10-ton coal wagon belonging to D. Davis and Sons. The link had apparently been originally of $1\frac{3}{8}$in. diam., but was somewhat worn and out of shape. The fracture was at the bow of the link, and was caused by an exceedingly faulty weld, in which there was a large flaw, little more than two-thirds of the total area being in contact. The diameter across the broken ends was $1\frac{9}{32}$ in. vertically and $1\frac{1}{8}$ horizontally. The metal of the link generally was so crystalline that when the link was pulled from the drawbar hook of the wagon behind, it broke into two separate parts, snapping also at the other end of the link and showing a clean fracture. The diameter at the end was $1\frac{12}{64}$ in. It will be seen that this coupling does not comply with the standard specification for private owners' wagons in that the weld was at the end of the link and not at one side, so presumably it was manufactured some years ago. It was impossible to detect the flaw, as it was in the centre of the link, and as there was metal holding all round it, no crack was visible on the surface.

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THE

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Contents.

Sir Fred. R. Upcott, K.C.V.O., C.S.I., late chairman of the Indian Railway Board, has been elected director and deputy-chairman of the East Indian R.

Mr. W. A. Mount has been elected a director of the Didcot, Newbury and Southampton R.

Mr. Thos. Evans, president of the S. Wales and Monmouthshire Freighters' Association, and of the Conciliation Board of Shippers and Coal Trimmers, and director of the Ocean and other Colleries, has been elected a director of the Barry R.

Lord Claud Hamilton, chairman, Great Easter R., has been elected a director of Hadfield's Steel Foundry Co., Sheffield.

Mr. H. G. Gregg, of Clonmore, Stillorgan, has been elected a director of the Midland Great Western R. of Ireland, in succession to **Sir Ralph Cusack,** who was for many years chairman, and who has now resigned his seat at the board.

Mr. Jas. C. Inglis, general manager, Great Western R., has been elected to be president of the Institution of Civil Engineers from November next.

Mr. Vincent Hill, general manager, South Eastern and Chatham R., has been made an officer of the Legion of Honour of France.

Mr. Cedric V. Godfrey, police superintendent, Midland R., has been appointed chief constable of Salford.

Mr. John Newlands, assistant stationmaster at Glasgow Central, has been appointed district traffic superintendent of the Caledonian R. at Edinburgh, in succession to **Mr. J. M. Kinghorn,** who has retired.

Mr. Edward Roche, of the L. and South Western R., has been appointed resident engineer of the Somerset and Dorset R., in succession to **Mr. J. J. Tyler,** who has removed to the engineers' department at Waterloo.

Mr. A. J. Pringle has been appointed chief assistant engineer of the Buenos Ayres Great Southern R., and **Mr. W. Jackson** has been appointed telegraph superintendent in succession to **Mr. J. Brayshaw,** who has retired.

*

North-Western New Irish Service via Kingstown.

THE attempt by the City of Dublin Steam Packet Co. to prevent the L. and North Western R. from using the Clarence Pier for their new day-service to Ireland has failed so far, Mr. Justice Eve dismissing the petition of right with costs.

The idea was that by using the Clarence Pier the L. and N.W.R. boats would interfere with the mail service, for which the City of Dublin Co. receive a subsidy of £100,000, being efficiently worked as heretofore. Should the City of Dublin Co. find the alleged difficulties to be insurmountable the remedy would appear to be simple, viz., to hand the service over to the railway as, presumably, they will have to do *when* the railways are nationalised.

*

Western Syndicate Cab Signal.

AFTER fourteen months' trial the Great Western R. Co. have now received an official intimation from the Board of Trade approving of the arrangements installed on their Fairford Branch. This approval not only applies to the use of the system as a cab-signal when fog prevails, but to the more important feature, viz., dispensing with the distant signals.

*

Conciliation Boards.

THE Board of Trade has issued the results of the "Railway Elections" on the Gt. Western, L. and South Western, Somerset and Dorset, Taff Vale, Alexandra Docks, Port Tabot, Rhymney, Hull and Barnsley, and L., Tilbury and S. railways. Occasionally, very occasionally, one of the candidates "run" by the A.S.R.S. has been defeated, but, generally speaking, they have been elected by substantial majorities.

The only exception worth mentioning is that on the G.W.R., the A.S.R.S. men failed to secure any of the six seats of the A or Loco. division—the men evidently preferring to be represented by men belonging to the Loco. Engineers' and Firemen's Association.

*

North-British R. Official Guide.

WE have received a copy of the N.R.B. Official Guide, the descriptive contents of which fully justify the title of *The Beauties of Scotland.* It is copiously illustrated, the illustrations being happily selected and well executed. The book is of a handy size for the pocket, contains a good map, and it is in every way equal, if not superior, to the American and German railway guides, about which so much is said by those who always prefer to extol foreign to home productions.

*

Medical Examination of Drivers.

IN his report of the result of his enquiry into the causes of the accident last January on the Chequerbent bank on the L. and North Western R., Col. Yorke says that he considers the erratic handling of the heavy banking engine was due to the fact that the driver was in the last stages of a fatal

malady, viz., diabetes, and remarks that the case "points to the desirability of a more frequent medical examination of engine drivers, especially after a man has been absent from duty for some months owing to a serious illness."

Both railway companies and the travelling public ought to be grateful to the Chief Inspector of Railways for this expression of opinion, and it is to be hoped that in future when there is any dispute as to whether signals are "on" or "off" the Board of Trade inspectors will take their courage in both hands and have the enginemen and others concerned properly examined medically. There would be, of course, great opposition to such examinations, as the following resolution passed on March 22nd, at Hull, indicates.

Eyesight Test.—" That this meeting protests against the " system of eyesight test at present in operation on the N.E. " We do not object to men joining the service of the company " being medically examined, but when once in the service " any further test should be of ability to perform his ordinary " duties."

Resolutions like the above strike terror into the Board of Trade, and the President recently stated in Parliament that new departures in the way of medical examinations for enginemen will not be justified at the present time. Quite recently the driver, W. Patterson, in charge of the 1.45 p.m. express from Newcastle to King's Cross, had a fatal seizure when the train was at Lamesley, four miles from Newcastle; the fireman took the train to Birtley, where the driver died, and where a porter was obtained, and, with his assistance, the train was taken to Durham, where another driver took charge. At the inquest the jury found that Patterson's death was due to fatty degeneration of the heart, and added a rider to the effect that drivers and firemen should be subjected to periodical medical examinations.

Surely, in this case we have all the elements necessary to cause a Shrewsbury disaster. The point which affects railway companies is whether, under the circumstances, they would be liable to pay compensation should an accident occur owing to the sudden death of the driver.

Col. Yorke continues to have a rough time at meetings of enginemen in consequence of his report on the Shrewsbury accident. He is accused of theorizing, and his analogies of men sleeping on horse and camel-back are rightly, we think, scoffed at. Col. Yorke would have done better to have examined and quoted from the Accident Bulletins issued by the Interstate Commerce Commission, and in which are recorded several known instances of bad accidents being caused through the driver being asleep. We quote two, one from the Bulletin for the first quarter of 1905—the fireman was killed, driver asleep, overran passing place where he should have stopped, result butting collision, driver awake three minutes before accident. Another from the Bulletin for third quarter of 1904—engineman fell asleep and entered yard too fast, fireman inexperienced, did not think to wake him till too late.

*

Russia's New Railway Passenger Fares.

THE *Messager Officiel* has just published the new law regulating the fares on the Russian railways. A verst is equal to about two-thirds of a mile. The new rate will be 2¼ farthings per mile third-class, including the State tax, for distances not exceeding 200 miles, but from 107 miles to 200 miles one farthing additional will be added to every verst ticket. From the 201st mile the fare will not in future be fixed according to the verst distance, but will be calculated by zone, and for this purpose any portion of a zone shall be regarded as the whole zone. The normal fare will not be applied to any distances over 2,007 miles, and for distances beyond 2,007 miles there will be an additional rate of 10*d.* for every zone of 47 miles. The new fares will come into operation on July 14th, New Style, for local traffic and through trains, and on November 14th in the case of trains running in the suburbs of the big towns. Annexed is the new schedule :—

201 miles to 333⅓ miles, 8 zones at 6¼*d* each.
334 miles to 473⅓ miles, 7 zones at 7½*d*. each.
474 miles to 660 miles, 8 zones at 8¾*d*. each.
660½ miles to 1,007 miles, 13 zones at 10*d*. each.
1,007½ miles 1,907 miles, 30 zones at 11¼*d*. each.
1,907 miles to 2,007 miles, 3 zones at 1*s*. 0½*d*. each.

*

Canadian Pacific Railway.

THE Canadian Pacific R. is a wonderful property. It owns a line extending from the Atlantic to the Pacific oceans with thousands of miles of branch lines. The last annual report gives the grand total mileage as 10,239 miles, including 823 miles under construction. It owns a line of steamers from Quebec to Liverpool and another from Vancouver to Yokohama; also lake and coast steamships. It owns the Dominion Express Company, which operates the express business over its lines; also the telegraph lines which serve its territory, and its own parlour and sleeping cars. It owns a controlling interest in two United States lines—the Duluth, South Shore and Atlantic (600 miles) and Minneapolis, St. Paul and Sault Ste. Marie (2,282 miles). It owns 14,800,000 acres of unoccupied land.

In a letter read before the Canadian Parliament last spring Sir Thomas Shaughnessy, president of the Company, showed that during the previous five years 28,000,000 dols. had been spent on equipment, 44,000,000 dols. on improvements to the existing lines, shops and roundhouses, and 35,000,000 dols. for new lines and new Atlantic steamers. Last year 700,000 dols. was spent on ocean, lake and river steamships, 4,500,000 dols. on construction of new lines, 11,000,000 dols. on additions and improvements, and 13,500,000 dols. on rolling stock, shops and machinery. The gross earnings were 72,200,000 dols., against 61,700,000 dols. in 1906, an increase of 17 per cent. The net earnings were 25,300,000 dols., against 23,000,000 dols. in 1906, an increase of 10 per cent.

During the year 5,946,779,961 tons of freight were carried one mile, the average receipts per ton per mile of revenue freight being 0·776 cents. The number of passengers carried (earning revenue) one mile was 1,052,286,316, the average amount received per passenger mile being 1·79 cents.

On June 30th, 1907, the rolling stock was as follows: 1,296 locomotives; 1,191 first and second class passenger cars, baggage cars and colonist sleeping cars; 224 first class sleeping, dining and café cars; 51 parlour, official and paymasters' cars; 40,405 freight and cattle cars; 722 conductors' vans; 2,108 board, tool and auxiliary cars and steam shovels. —*American Engineer.*

*

"Webb" Prize and Indian Premium, Inst. Civil Engineers.

THE Council of the Institution of Civil Engineers announce that they have accepted on behalf of the Institution the legacy of £1,000 bequeathed by the late Mr. F. W. Webb, for many years chief mechanical engineer of the L. and North Western R., to be applied to establish a "Webb Prize," to be awarded by the Council once in every three years, or oftener, as the Council may think fit, for the best Paper submitted to the Institution on "Railway Machinery," or upon some branch of Railway Machinery which may be prescribed by the Council.

The Council also propose to award annually a prize to be called the "Indian Premium" to the Author (being a corporate member of the Institution in practice in India) of the best Paper received during the year on a subject connected with Indian engineering. This special award, which when made will be irrespective of any other recognition of the merits of such Paper which the Council may accord to it in the ordinary course, is derived from the proceeds of certain trust funds conveyed to the Institution on the closing of the Royal Indian Engineering College, and will be of the value of about £33 annually.

*

Locomotives for Queensland.

QUEENSLAND has entered upon a brisk railway-constructing policy, and has ordered 25 locomotive engines from Kitson

and Co. The Government of Queensland has also given orders for the construction of 25 engines locally, making 50 in all.

Books Received.

The Statute Law Relating to Patents of Invention and Registration of Designs, with an Introduction and Synopsis. By J. W. GORDON, Barrister-at-Law. Jordon and Sons, Ltd., 116 and 117, Chancery Lane London, W.C. 1908. [210 pp.; 8¾ by 5½; price, 5s. net.]

Structural Engineering. By A. W. BRIGHTMORE, D.Sc., M.Inst.C.E. With numerous diagrams. Cassell and Co., Ltd., London, Paris, New York, Toronto, and Montreal. 1908. [280 pp.; 8¾ by 5⅜; price, 10s. 6d. net.]

Practical Induction Coil Construction. A handbook of constructive details and workshop methods used in building and repairing modern spark coils. By JOHN PIKE. Illustrated with original photographs and drawings. London: Perceval Marshall and Co., 26-29, Poppin's Court, Fleet Street, E.C. [128 pp.; 7¼ by 4⅞; price, 1s. net.]

The Nationalisation of Railways. By A. EMIL DAVIES. London: Adam and Charles Black. 1908. [125 pp.; 7¼ by 4⅞; price, limp cloth, 1s. net.]

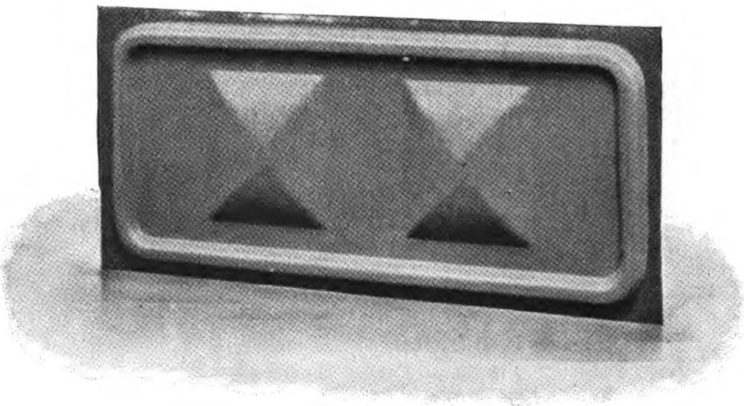
The Strength of Chain Links. By G. A. GOODENOUGH and L. E. MOORE. Bulletin No. 18 of the University of Illinois Engineering Experiment Station, Urbana, Ill., U.S.A.

The Electrification of Railways. By PROF. GISBERB KAPP, Dr. Eng. Two lectures delivered before the Royal Institution of Great Britain, January, 1908. London: Biggs and Sons, 139-140, Salisbury Court, E.C. [45 pp.; 11in. by 8½in.; price, paper cover, 1s.]

Lane's Pressed-Steel Corrugated Wagon Door.

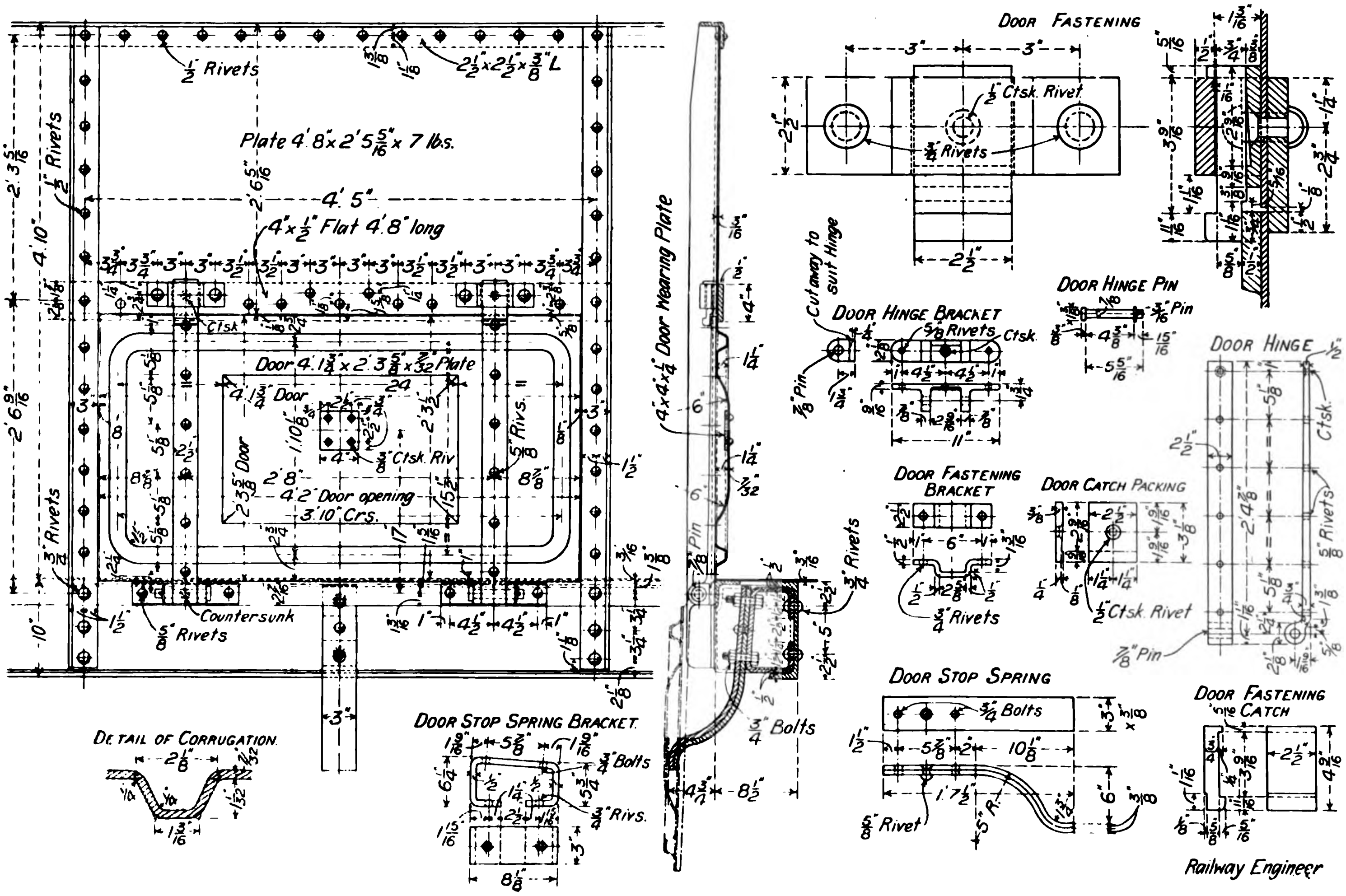
THOSE who have had experience in making ordinary plate wagon doors stiffened with frames or strips will readily appreciate the advantages of the new door patented by Mr. F. Lane, general manager of the Leeds Forge Co., and which is illustrated by the annexed drawings.

The plates of ordinary doors are frequently thrown out of truth by the riveting on of the strips and hinges, and it is then not an easy matter to level the plate and get it out of "winding." But Lane's door is much stiffer than it is possible to make a door with strips or even with a frame having welded corners. It is pressed out of a single steel plate $\frac{7}{32}$in. thick, dished inwards to a depth of 1¼ins., and having a continuous corrugation of the same depth all round near the edge, as shown. In the case of double doors the edge of one is joggled over the other and no joint strip is required.



Goods wagons are frequently specified to be free from projections on the inside; to meet this the corrugations can be made specially rounded in form, and if necessary the dishing and corrugations can be on the outside of the door instead of inside, the plate being kept flat where required to take the hinges.

From an actual test made, under the supervision of Mr. J. Falshaw Watson (Inspector for the Leeds District for Sir John Wolfe Barry and other engineers), with two doors of the same size, 4ft. by 2ft., each supported at two opposite



Lane's Pressed-Steel Corrugated Wagon Door.

edges, 3ft. 10in. centres of supports, and loaded in the centre (one door being a corrugated door and the other a built-up one of the ordinary type), it was found that the corrugated door, notwithstanding the fact that its weight was only 80 % of that of the built-up one, deflected only a quarter as much as the latter.

The built-up door was $\frac{3}{16}$in. thick, stiffened with a frame $1\frac{7}{8}$in. by $\frac{1}{2}$in. weighing 94 lbs. loaded in the centre with 25 cwts., deflected $3\frac{3}{8}$in., with a permanent set of $2\frac{1}{16}$in.; with a load of 30 cwts. the door collapsed.

The corrugated door was $\frac{7}{32}$in. thick and weighed 75 lbs. It deflected $\frac{9}{32}$in. and $\frac{5}{16}$in. respectively with the same loads, without any permanent set.

These doors are fitted to the Leeds Forge Co.'s own high capacity coal wagons and may be seen by anyone interested, and large numbers of them have been fitted on wagons for Indian, Egyptian, South American, South African, Chinese and other railways.

Board of Trade Returns as to Failures of Rolling Stock and Rails

THE issue recently of the Board of Trade report on the derailment at Wembley* naturally leads one to search the annual returns as to the frequency of accidents due to similar causes—a broken spring of the engine tender.

In going through these figures we found much that is interesting and instructive, and, at the same time, there are many items as to the accuracy of which we have doubt and which, as published, lead to a false impression of the position if the figures be incorrect, as we are inclined to think they are.

Under the Railway Regulation Amendment Act of 1871—34 and 35 Vict. c. 78—section 6 provides that notice must be sent to the Board of Trade of "(1) any accident attended with loss of life or personal injury to any person whomsoever; (2) any collision where one of the trains is a passenger train; (3) any passenger train or any part of a passenger train accidentally leaving the rails; (4) any accident of a kind not comprised in the foregoing descriptions but which is of such a kind as to have caused or to be likely to cause loss of life or personal injury and which may be specified in that behalf by any order to be made from time to time by the Board of Trade."

All such mishaps as reported by the companies are tabulated and presented annually in the "General Report to the Board of Trade on the accidents that have occurred on the Railways of the United Kingdom," the last available one being for 1906, and in Table No. 12 of Appendix A thereof is a summary of the number of such accidents and failures as have been reported to the Board of Trade. The accidents are sub-divided into eleven heads and the failures into thirteen.

From this Table we find that during 1906 there were 40 collisions between passenger trains or parts of passenger trains and 37 collisions between passenger trains and goods or mineral trains or light engines. Then there were 75 cases of passenger trains or parts of passenger trains leaving the rails. But there were only 35 collisions between goods trains or parts of goods trains and light engines and only 19 cases of goods trains or parts of goods trains, light engines, etc., leaving the rails. We are inclined to believe that the companies faithfully report all passenger train accidents, but it is hard to credit that they do all that the Act of 1871 demands of them as regards goods trains and light engines. The Act says "any accident . . . . of such a kind as . . . to be likely to cause . . . . personal injury." Surely personal injury is possible in all collisions and in all derailments of light engines, but the decision would seem to rest with the clerk responsible for sending in the reports to the Board of Trade.

We now come to the point that first attracted our attention and which led to these observations. Under the heading of accidents to or failure of rolling stock or permanent way there are various sub-divisions. By anticipating part of our subject somewhat and giving the number of some of these failures for the years 1904-5-6 and the mileage run during those years, and making comparisons with the year 1875, we can show what some of these sub-divisions are.

Year	1875	1904	1905	1906
Train miles, millions	209	397	400	414
Bursting of boilers or tubes, etc	20	6	4	9
Failure of machinery, springs, etc.	14	6	2	10
Failure of tyres	660	158	160	137
Failure of wheels	112	1	1	1
Failure of axles	478	134	131	148
Failure of couplings	29	13	40	21
Broken rails	476	335	266	264

It will be noticed from the above that there were 137 cases of failures of tyres. From the return we learn that 60 of these were on "private owners'" vehicles. This leaves 77 as occurring on the vehicles belonging to railway companies. Out of these it is stated that 36 occurred on those owned by the L. and North Western R. In order that we might be certain that this was not a misprint we turned to the reports for 1904 and 1905, but found the same strange fact—35 out of 78 and 42 out of 80.

Knowing that the rolling-stock—both goods and passenger—of the North Western is of the best, one is forced to the conclusion that they put an interpretation as to what has to be reported that is not shared by other companies—at least not the leading ones.

It would seem then desirable that action should be taken by the Board of Trade to obtain uniform returns on all points that have to be reported upon, and also whether the tyres and axles which fail are of continental or British make.

From the summary for 1906, from which the foregoing figures are taken, we learn that of the 137 tyres which failed 14 were engine tyres, 3 were tender tyres, 1 was a coach tyre, 15 were van tyres, and 104 were wagon tyres. Of the wagons, 60 belonged to owners other than the railway companies; 53 of the tyres were made of iron and 84 of steel. One tyre was fastened by Gibson's patent method, 4 by Mansell's, 122 by bolts and screws—one of which left the wheel when it failed—and 10 by other methods—2 of which left the wheels when they failed; 28 tyres broke at screw or bolt-holes, 63 transversely and 46 split longitudinally or bulged. Of the 148 axles which failed, 93 were engine axles, viz., 68 crank or driving and 25 leading or trailing, 15 were tender axles, 9 were coach axles, and 31 were wagon axles. Of the wagons, 11 belonged to owners other than the railway companies. Of the 68 crank or driving axles, 15 were made of iron and 53 of steel. The average mileage of 14 of the driving axles made of iron was 275,797 miles and of the 53 crank or driving axles made of steel 230,731 miles. Of the 264 rails which broke 22 were double-headed, 176 were single-headed, and 66 were Vignoles' rails. Of the double-headed 9 had been turned. All the rails were made of steel.

One-Wire Three Indication Block Instrument; Moore and Powles' Patent.

WE were recently afforded an opportunity by the Walters' Electrical Manufacturing Co., Ltd., of inspecting a pair of these new Block Instruments at the Kensaltown Telegraph Works, London, W.

The great advantage hitherto possessed by the three-wire type of Block Instrument is that it gives three visual indications, viz., "*line-closed*," "*line-clear*," and "*train-on-line*," and which is a most essential condition of the usually adopted "affirmative" system of working trains. With Moore and Powles' new instruments, illustrated herewith, these three indications are obtained, from either end of the line, by means of momentary currents and with the use of one line wire only.

Fig. 1 is an external view of the instrument, and fig. 2 is

*This report will duly appear in our pages.—ED. *R.E.*

a diagram of the electrical connections of the upper or "*train-going*" dial.

The current sending portion consists of a circular commutator with an external index finger which can be moved to point to a white, green, or red tablet, and in these three positions respectively denotes that if the plunger be depressed "*line-closed*," "*line-clear*," or "*train-on-line*" will be sent to the cabin in the rear. This index finger does not need to be nicely adjusted by the signalman, to point to the desired coloured tablet, but is turned by the milled head of the commutator quickly to the required position, where it is brought up by a dead stop. The commutator is then mechanically locked in this position until the plunger has been depressed, thus actually sending a visual and an audible signal to the distant cabin. It can also be made compulsory that when "*line-clear*" has been sent out, "*train-on-line*" must also be given before the normal position of "*line-closed*" can be again obtained. In a like manner, when "*train-on-line*" has been sent, "*line-clear*" cannot be given until "*line-closed*" has been signalled; but "*train-on-line*" can be immediately sent, from either the "*line-clear*" or "*line-closed*" positions.

The commutator is the same as that of Moore and Powles' Block Instrument and which was fully described and illustrated in the *Railway Engineer* for January, 1905.

Two 8-cell ordinary Leclanche batteries are sufficient for working the instrument. These are joined up to the commutator so that one only, or the two combined, are used for sending currents to line. If we speak of the current from one battery only as "weak," and from the combined batteries as "strong," the following currents are respectively sent for the three indications :—

"*Line-closed*," strong zinc current to line.

"*Line-clear*," weak copper current to line.

"*Train-on-line*," weak zinc current to line.

When the plunger is depressed the current goes out to line through the bottom or "*train-coming*" dial, and, according to its polarity, drops either the "*line-closed*" or the "*line-clear*" indication. If, however, a strong zinc current is sent, the "*line-closed*" indication is dropped, and this eclipses the "*train-on-line*" indication, which also drops. Whichever indication is dropped remains in view until the commutator is turned to a new position, when it is mechanically replaced and the bottom dial shows blank until the plunger has again been depressed, and the the desired signal actually sent to line, when the new indication comes into view.

The incoming line current passes, fig. 2, through the electro-magnet which energises "*line-clear*" flag, through the double tongue circuit reverser and out to earth. The local circuit operated by this circuit reverser contains the electro-magnet which operates the "*train-on-line*" flag. The "*line-closed*" indication is fixed but can be eclipsed by the "*train-on-line*" flag, which in turn can be eclipsed by the "*line-clear*" flag.

The two armatures on the circuit reverser are so designed that, whereas A will readily respond to a weak current, B will only be attracted by a strong current. By following the connections on the diagram it will be understood that with a weak zinc line current (which only actuates armature A), the "*train-on-line*" flag electro-magnet is energised with a certain polarity which brings into view the "*train-on-line*" flag.

Fig. 1.

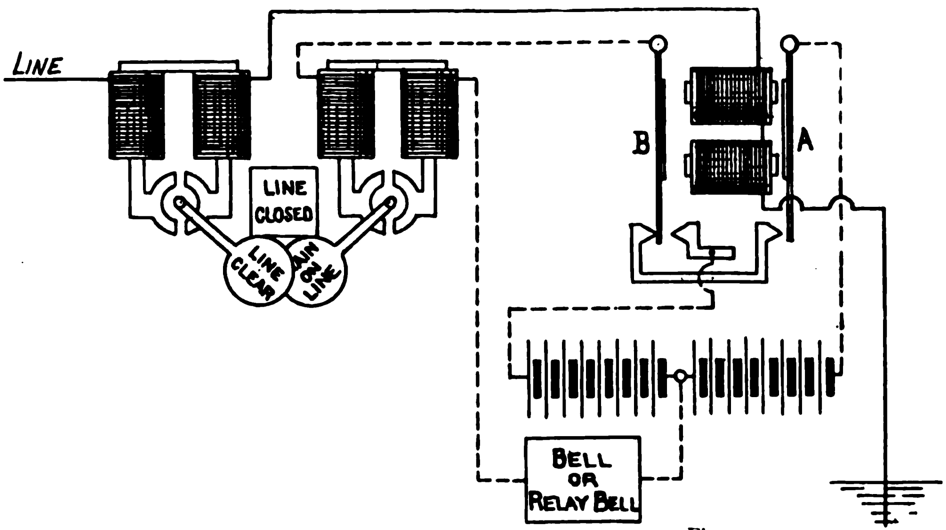


Fig. 2.

Moore and Powles' One-Wire 3-Indication Block Instrument.

With a strong zinc line current armature B is also attracted. The local circuit will then be of the opposite polarity, and "*train-on-line*" flag electro-magnet being energised in the opposite direction, the "*train-on-line*" flag is moved away and discloses the fixed "*line-closed*" indication. If, however, the line current is of copper polarity, then "*line-clear*" flag is brought into view, eclipsing any other indication. Thus, a line current of copper polarity brings into view "*line-clear*," whilst a line current of zinc polarity moves or keeps this flag out of view and shows "*line-closed*" or "*train-on-line*," according to whether the zinc current is strong or weak.

The three indications need not necessarily follow each other in the same cycle. "*Train-on-line*" can be given direct from "*line-closed*" or "*line-clear*."

The mechanism of the instruments is very simple, strongly made, and not at all likely to be affected by climatic changes or to get out of order. The case is jointed and when unlocked the top portion lifts off quite clear of the wire connections and leaves the instrument exposed all round.

The advantages of the instrument are briefly as follows :—

As these instruments perform efficiently all the functions of the three-wire instruments, their use would save the cost of erection and maintenance of two line wires between every signal cabin.

Momentary currents being used, there is no consumption of battery power except when a signal is being sent. As only one indication is visible it cannot be mis-read. Only one transmitting plunger is used and the instrument is easily manipulated with one hand.

When the commutator is moved to a new position the "*train-coming*" dial shows blank and the indication does not appear until the plunger has been used and the required signal actually sent to line.

"*Line-clear*" cannot be sent or received in mistake for "*line-closed*" or "*train-on-line.*"

Sleeping Saloons: L. & South-Western Railway.

FOUR very fine sleeping saloons have recently been built at the Eastleigh Carriage Works of the L. and South-Western R. to the designs of Mr. S. Warner, who has kindly furnished us with the photographs from which our illustrations have been made..

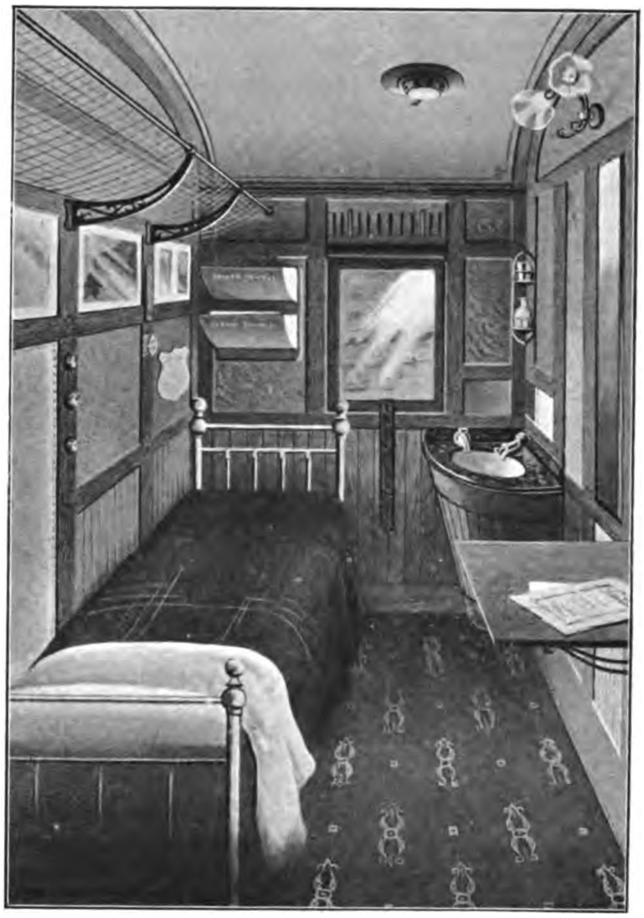
These cars, which are luxuriously furnished and fitted throughout, are intended for the night boat-trains between Plymouth and London (Waterloo) in connection with the White Star American steamers and the West African mail services.

In an early issue we shall publish drawings of these saloons, but in the meantime the following general particulars will be of interest.

Length over the bodies, 56ft.; width over the bodies at the waist, 9ft.; length between centres of bogies, 39ft. The wheelbase of the bogies is 8ft., and particular attention has been given to the springs to ensure easy riding. Each car is divided into 7 single-berth and 2 double-berth compartments, an attendant's compartment, a lavatory, and at each end a vestibule entrance.

The sleeping compartments are finished in polished wainscot oak fascias, Hungarian ash panels, and Ply wood roofs painted with white and lined with gold. The corridor and lavatory are finished in wainscot oak and polished Ply wood, with figured oak panels below the waist. The vestibule entrances are finished throughout in polished mahogany, and altogether the interiors give a cheering and bright appearance.

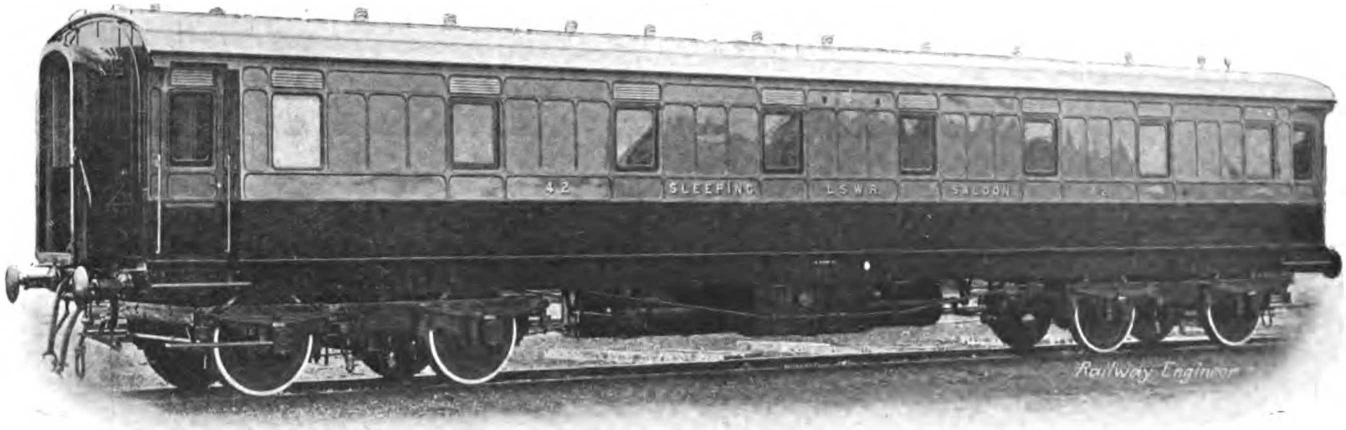
In so far as the berths are concerned, these cars are a distinct departure from those running on other companies' systems, inasmuch as they are furnished with brass bedsteads, specially designed and manufactured for these cars by Petts and Co., Manchester, upholstery having been entirely eliminated; in fact, with the exception of a small Moire silk pad against each pillow, no trimming whatever has been used. This renders the cars most hygienic, as the polished woodwork can be kept scrupulously clean, and when desired the bedsteads may be taken down in a few moments and the compartments thoroughly cleansed.



Interior of Sleeping Compartment.

Each sleeping compartment is fitted with steam heating so arranged as to be under the control of the occupant. The wash basins are supplied with both hot and cold water, and electric bells are fitted communicating with the attendant.

The cars are electrically lighted throughout with Stone's system; the lamps so arranged that passengers may have a full or glow light as they desire. For reading purposes one lamp only can be switched on at the head of the bed. In outward appearance the vehicles are in unison with the standard South Western stock.



Sleeping Saloons; L. and South Western Railway.

Roofs — VIII.*

The roof principal shown in figure 51 is of a peculiar type and is provided with a raised portion, usually glazed and provided with louvres. The loads on the left half of the roof are vertical only, whilst those on the right-hand side are a combination of vertical dead loads and horizontal wind loads. Both supports are presumed to provide inclined reactions.

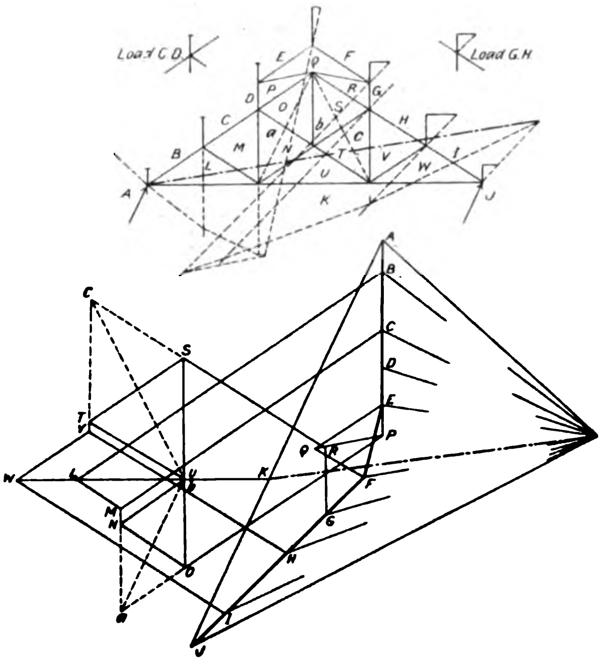


Fig. 51.

The load diagram is laid down in the usual way, A B C, etc., to J, and the straight line resultant AJ for the two reactions. The latter are obtained by means of the closing line of the funicular polygon when a line is drawn parallel to the closing line through the pole of the vector diagram, giving the point K in the straight line AJ.

The position of the point K being thus found, it becomes a simple matter to lay down BL, KL, IW, KW, and then by means of IW and the load HI to find HV and WV, and from BL and BC to obtain CM and LM.

At the next joints, however, difficulties arise, in that two known loads have to be resolved into three directions at both joints, which is, of course, impossible to determine as the bars stand.

It is therefore necessary to temporarily remove bars NO, NU, ST and TU, and to replace these by the temporary bars ab, bc shown by dotted lines.

It is now necessary to discuss the effect of the loading from the raised portion of the roof before going further. Here then there is the apex load EF, which is set off along EQ and FQ, as in the stress diagram, and from point Q so found we draw QP and QR, the point P being upon a vertical line dropped from D, and point R upon another vertical line raised from G.

The reason for this is obvious when it is considered that, given the stress EQ and the load ED, the lines QP and DP are essential to complete the reciprocal figure of the bars at the foot of the bar EQ, whilst on the other side of the roof, where we know the stress FQ and the load FG, the two lines QR and GR are necessary to close the reciprocal figure.

Hence for the joint at the top of bar Ma we have the known loads CD and DP and stress CM, a resultant is produced PM which is resolved into Ma and Pa, whilst on the other side the stress GR, the load GH, and the stress HV produce the resultant RV, which may be resolved into RC and VC.

The position of points a and c thus obtained in the stress diagram, we now consider the joint at the foot of the vertical bar Ma. Here then we have already found the horizontal stress KL, the included stress LM, and the vertical stress Ma, which combined produce a resultant Ka, which is resolved into the two bars Kb and ab.

For the corresponding joint on the other side of the truss there are the stresses KW, VW, and Uc, with resultant Kc, which may be resolved into Kb and ab.

Of course the point b found in this way from both sides should superpose accurately to prove the correctness of the drawing.

Now it is obvious that Kb in the truss diagram is identical with KU when the temporary bars are removed and the permanent bars replaced, and this being the case, at the joint at the foot of Ma we have the stresses found KU, KL and LM, with resultant UM, which is to be resolved into MN and UN; and for the top joint of the same vertical the stresses CM, MN, and load CP give a resultant PN, which is at once resolved into NO and PO.

In the same way for the joint at the foot of the vertical VC, with the stresses KW, WV and KU known, the resultant UV is resolved into UT and VT; and for the top of the same bar the stresses HV, VT and the load RH known, resultant RT, it is an easy matter to resolve this into RS and TS, and if a vertical line be drawn from S to O the diagram of stresses is complete.

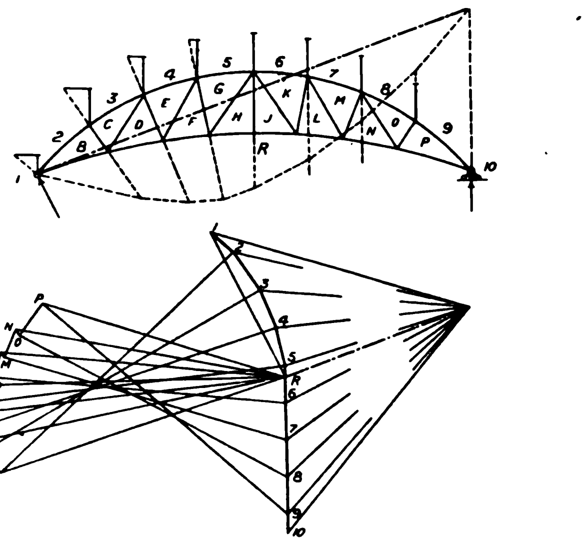


Fig. 52.

The roof truss shown in fig. 52 is a crescent truss, in which both the lower and the upper chords are segments of circles, and the alternate braces are radial to the curve of the upper chord, the right-hand bearing is assumed to be free, whilst the left-hand side is fixed.

The dead loading is, of course, symmetrical on both sides of the roof, whilst the wind is one side only, and in the diagram this is assumed to be on the fixed or left-hand side.

*The previous articles of this series appeared in the *Railway Engineer* as follows:—I., May, 1907; II., July, 1907; III., September, 1907; IV., October, 1907; V., December, 1907; VI., February, 1908; VII., April, 1908.

The first thing is to find the values of the two reactions, and this is done by the use of the funicular polygon, which, working from the pole gives a closing line cutting a vertical line, drawn upwards from 10 in the stress diagram, in the point R, to give the vertical reaction at the free abutment where only a vertical load is allowable.

If a line is drawn from R to I, this gives the direction and value of the inclined reaction at the point of support at the left-hand or fixed support.

Now, to make the stress diagram, from 2 draw a line parallel to the upper chord in the direction of 2B and another line from R parallel to RB of the outline diagram, until the two lines meet in the point B.

For the first joint in the upper chord we have found stress 2B, and the load 2 3 being known, the resultant 3B is resolved into BC and 3C, and for the lower joint, RB and BC being known, with the resultant RC, it is easy to resolve this into CD and RD.

Going along to the next upper chord joint, we have 3C and CD and 3 4 being already known, with resultant 4D, this is resolved into DE and 4E; whilst for the lower chord joint, the stresses RD and DE being known, and the resultant RE, this is resolved into EF and FR.

So in like manner for the next upper joint, 4E, EF and 4 5 known, we can draw FG and 5G, and this is continued until the whole of the bars are set down.

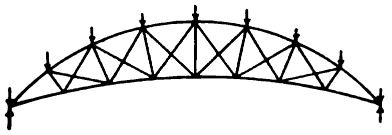


Fig. 54.

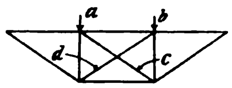


Fig. 55.

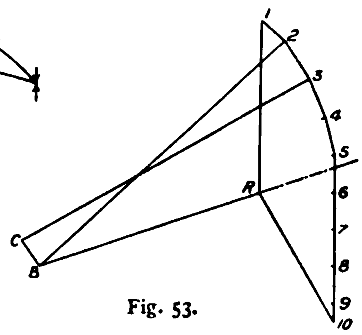


Fig. 53.

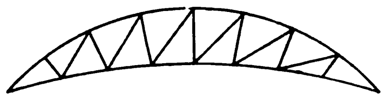


Fig. 56.

Now imagine that the fixed and moveable ends are reversed, the fixed end at the right-hand side and the free end at the left-hand side (see fig. 53).

A new load and reaction diagram has now to be drawn, and it will at once be noticed how different the stresses are when produced under the second condition than they were in the case of the first arrangement of bearings.

Here then, to begin with, we first draw the funicular polygon with its closing line, and instead of raising a vertical line upwards from point 10 we drop a vertical from 1 until it cuts into the closing line at R. This gives the reaction at the left-hand or free side, whilst for the other reaction on the opposite side a line drawn from R to 10 gives the direction and value that is required.

Following the same procedure as in the first case, lines are drawn from 2 and R until they meet in B, and this point found, BC and 3C are next drawn. It is not necessary to continue the description of the diagram since it simply follows the procedure of the first case. Some of the lines may go downwards instead of upwards, or may disappear altogether, but the correctness can always be verified if the lines meet in the proper point when the diagram is constructed from both ends of the truss until they meet in any intermediate point.

At this point it may be noted that most roof trusses have double bracings, as in fig. 54, and that therefore a resultant has to be resolved into three directions, or, in other words, that the problem is intermediate at every joint.

In some cases it is assumed that all the bracings or diagonals act as tension members only, and in this case any member that would act in comparison is omitted from the stress diagrams.

Several conditions of the loading should be considered, and it will probably be found that in some cases a bar will be in compression, under which condition it will be omitted; whilst in other cases it will be in tension and will be included.

Hence some of the diagonals will appear in certain of the stress diagrams and will disappear in other stress diagrams.

Thus for a truss as fig. 55, if the one load was at 'a' the bar 'c' would be omitted, whilst if there was one load at 'b' the bar 'd' would be omitted. In the case of two equal loads being on the truss at the same time the braces 'c' and 'd' would not be required at all and could be dispensed with so far as regards the theory of the truss. If, however, the loads were at all unequal then one or other or both of the bars should be used.

After all, the question of whether to consider the diagonals only that are in tension is a matter of design only and can only be decided by a reference to the working drawings of the roof.

If, for instance, the truss is made up of timber beams and round rods, or even if the booms and some of the bracings are built up of angle irons, whilst others are made of flat iron or steel bars only, then in this case it is obvious which bars are only capable of resisting tension.

For an unsymmetrical load such as occurs when wind is blowing on one side of a roof, and where the bars are designed only to resist tension, the figure 56 may be the outline to be considered and a new stress diagram must be drawn for this arrangement.

It may even be necessary to make independent stress diagrams for each of the systems into which the stress can possibly be decomposed.

If there are two systems of diagonals the load may be assumed to be equally distributed between the two, and if this is the assumption made it is frequently found that one stress diagram can be drawn which will meet the case, but this arbitrary division of loading may not be the fact of the case.

In some instances the bars will drop out of the stress diagram automatically when the stresses are graphically developed, that is, the bars are not required, are redundant, and are therefore not required for the condition of loading for which the strees diagram is made.

We now complete this series of articles on the graphic statics of roof trusses by the consideration of the American form of truss shown in figure 57. This truss is frequently found over railway sheds and workshops and consists of two straight upper chords with a curved lower chord, and a ventilator is placed over the ridge. The first strut from the support on each side is drawn round to the upper chord, whilst the lower chord is an arc of a circle except in the two

end bays, where the panel length is drawn parallel to the straight upper chord above it.

The left-hand support of the truss is assumed to be fixed whilst the right-hand support is assumed to be moveable. The effect of wind is provided for at both the vertical surfaces 1 and 6, whilst wind loads normal to the back of the roof are taken at each panel point of the truss. For convenience, instead of lettering the bays with the letters of the alphabet,

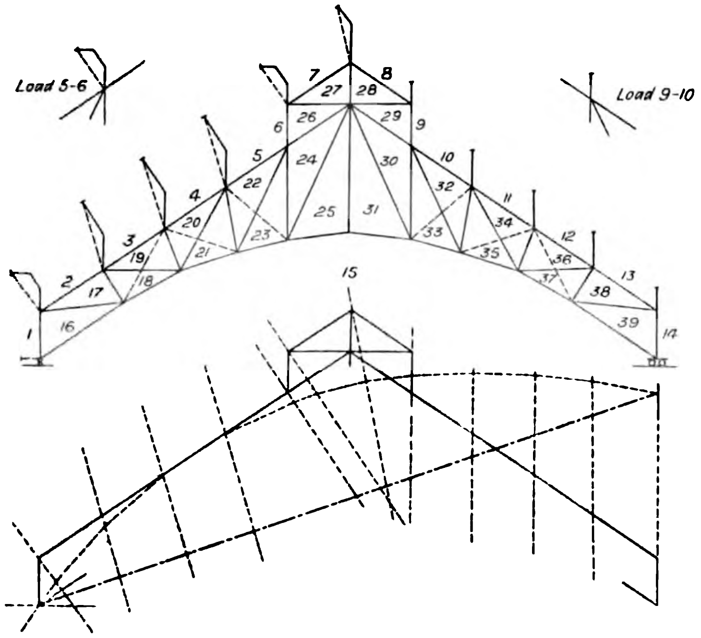


Fig. 57.

figures are used, as there are so large a number of panels to be marked. After marking off at each panel point the various vertical dead loads, the inclined and horizontal wind loads, and obtaining the resultant at each point, as indicated on the outline diagram, a funicular polygon is drawn, as in fig. 58, and a closing line is found in the manner shown in the lower diagram of fig. 57. This lower diagram is purposely drawn to show the direction of the various loads, and the manner in which these lines are cut by the funicular polygon to obtain the closing line.

Having set down the loads in fig. 58, a vertical is raised from 14 until it cuts the closing line of the vector polygon at 15, this gives the vertical reaction at the right-hand; then another line, this time inclined, is drawn from this point to 0, to give the value and direction of the other reaction, which, being fixed, is inclined.

The horizontal load 0 1 is external and does not come into the consideration, but if a vertical line be dropped from 1 and an inclined line drawn parallel to the bar in the truss from 15 to 16 the required stresses to begin with are found.

Then for the first joint in the upper chord we have the stress 1 16 and the load 1 2 known, with resultant 2 16, which is decomposed into 2 17 and 16 17, and for the next joint in the lower chord, the stresses 15 16 and 16 17, with the resultant 15 17, are resolved into 17 18 and 15 18.

For the upper chord joint the stresses 17 18 and 2 17, with the load 2 3 being known, the resultant 3 18 is found, which is resolved into 18 19 and 3 19.

Now, leaving the dotted lines out of the consideration, it is better to go on to the next point in the top chord, where there are only two indeterminate bars, whereas if the next lower joint there would be three indeterminate bars, which could not be solved. Here then we have 3 19 and 3 4 known, resultant 4 19, which is resolved into 4 20 and 19 20. Having found 19 20, we can go on to the lower joint, where we have 15 18 and 18 19 with 19 20 known, which gives 15 21 and 20 21.

Going back to the top joint, we have 4 5 and 4 20 with 20 21 given, with resultant 5 21, from which we can obtain 5 22 and 21 22. In the same way, with 21 22 and 15 21 known, draw 22 23 and 15 23.

Again, at the top we have load 5 6 with stresses 5 22 and 22 23 known, to which must be added the vertical component of load 6 7, which is drawn on the stress diagram as 6 26. The combination of these loads and stresses gives the resultant 26 23, which is resolved into 26 24 and 23 24, and this side of the roof will be completed if we work out the stresses at the lower joint, where we have 23 24 and 15 23 known, with resultant 15 24, which is decomposed into 15 25 and 24 25.

Now cross over to the other side of the roof, where there is only a vertical reaction and working through the various joints in the same way, a point 31 is found which, if the diagram is correctly drawn, will be exactly vertically over the point 25 already found from the left-hand.

If 31 and 25 are then connected by a vertical line the stress diagram is complete except as regards the raised portion of the roof at the central ventilator, the stresses for which can either be superimposed on the diagram already drawn, or a special stress diagram for this portion can be made.

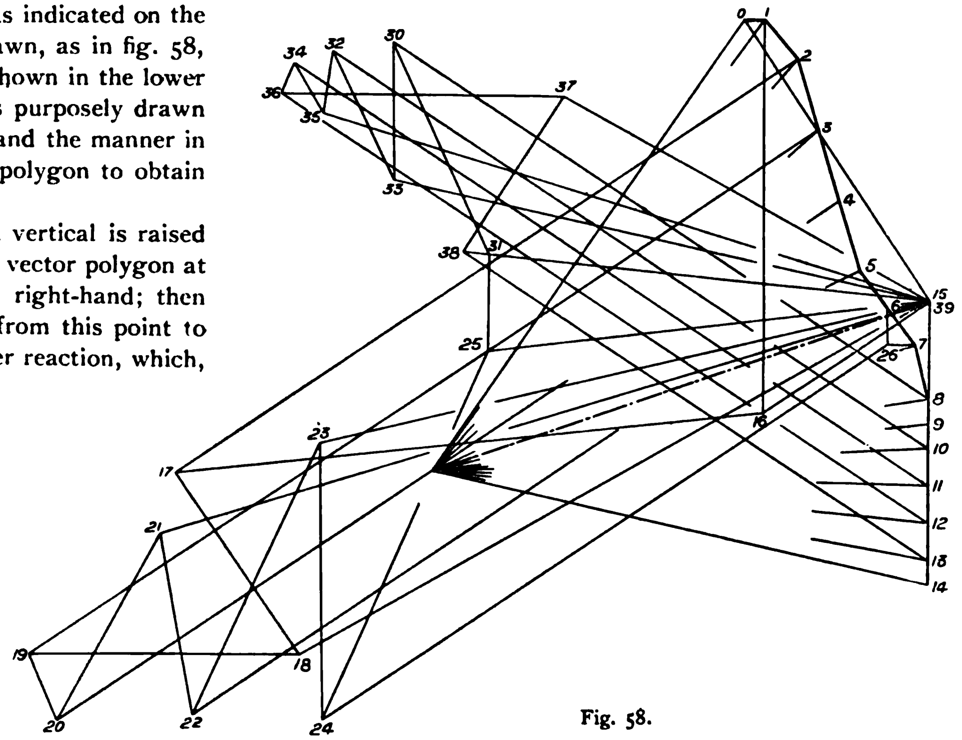


Fig. 58.

As may be gathered, however, from the previous remarks, this by no means exhausts the stress diagrams that it will be necessary to make for this truss if it were to be actually built. A special stress diagram should be made for each condition of loading, which are—

(a) dead load only;
(b) snow load only, both evenly distributed and also if the loading is on one side of the roof only;
(c) wind load on one side, with the bearings fixed and moveable, as indicated above;
(d) wind load on the same side, but with the bearings reversed, that is, the moveable reaction on the left side and the fixed reaction at the right side.

It may be found that under certain conditions of loading and bearings the dotted diagonal members will be thrown into tension and will therefore come into play. It will be necessary to make a table showing the stresses in each bar under each condition of loading, each stress when tabulated being marked carefully whether in tension and compression, so that the maximum and minimum stress, with the respective sense, whether tension or compression, may be noted.

Further, it would be well to take the case where both bearings are fixed, and not one only, since at any time the moveable bearing, whichever side it is on, may become jammed, and therefore must produce an inclined reaction, tending to modify many of the stresses.

(To be continued.)

The Curzon Bridge at Allahabad.*

THIS bridge over the Ganges, consisting of 15 spans of 200ft. girders, carries a single line of railway between the girders and a cart-road on the top booms.

The Ganges, in the vicinity of Allahabad, runs between practically permanent banks about 3 miles apart, but at the site chosen the width narrows to 6,350ft. The artificial narrowing of alluvial rivers, in order to reduce the cost of bridging, has received considerable attention in India of late, and the Curzon Bridge is believed to be the boldest example of this which has yet been attempted. The naturally reduced width of 6,350ft. has been still further constricted by closing half of this width by a solid embankment, protected from attack by a stone-faced training-bund or guide bank, which forces the river through a width of 3,165ft., which is bridged. The saving effected by this treatment has been about 15 lacs of rupees, or £100,000. So large a reduction in cost is not obtained without taking some risk, and the success of the undertaking depends, in the first instance, on the possibility of constructing in one season a solid embankment and so much of the training-bund as are essential to force the river through the constricted width. For if the embankment is breached and the river, as may happen, takes a course through it, much extra expense and great delay may result.

The successful construction in one season of the solid embankment to a sufficient height above high-flood level and of the whole of the training-bund, with its rubble stone protection, are described. Stress is laid upon the design and construction of the training-bund, which is believed to be the largest yet attempted in India.

The paper also deals with the difficulties experienced in sinking the well foundations to an average depth of 100ft. below low-water level, and especially with the difficulty of sinking into the substratum of clay met with an approximately this depth. The author, realising the importance of weight in sinking well foundations, puts forward for criticism a diagram of minimum sinking-effort or force per square foot of skin surface required for sinking through sand to various depths, for use in the design of wells.

The construction of the stone piers, 60ft. high, and the erection of the girders is described, and an account is given of the roadway, the steel road-viaducts, and the bank approaches. The viaducts are carried on cast-iron screw-piles, screwed into a made bank in the case of the viaduct at the left abutment, the bank at this point being 75ft. high.

* Abstract of a paper by R. R. Gales, F.C.H., M.Inst.C.E., read before the Institution of Civil Engineers.

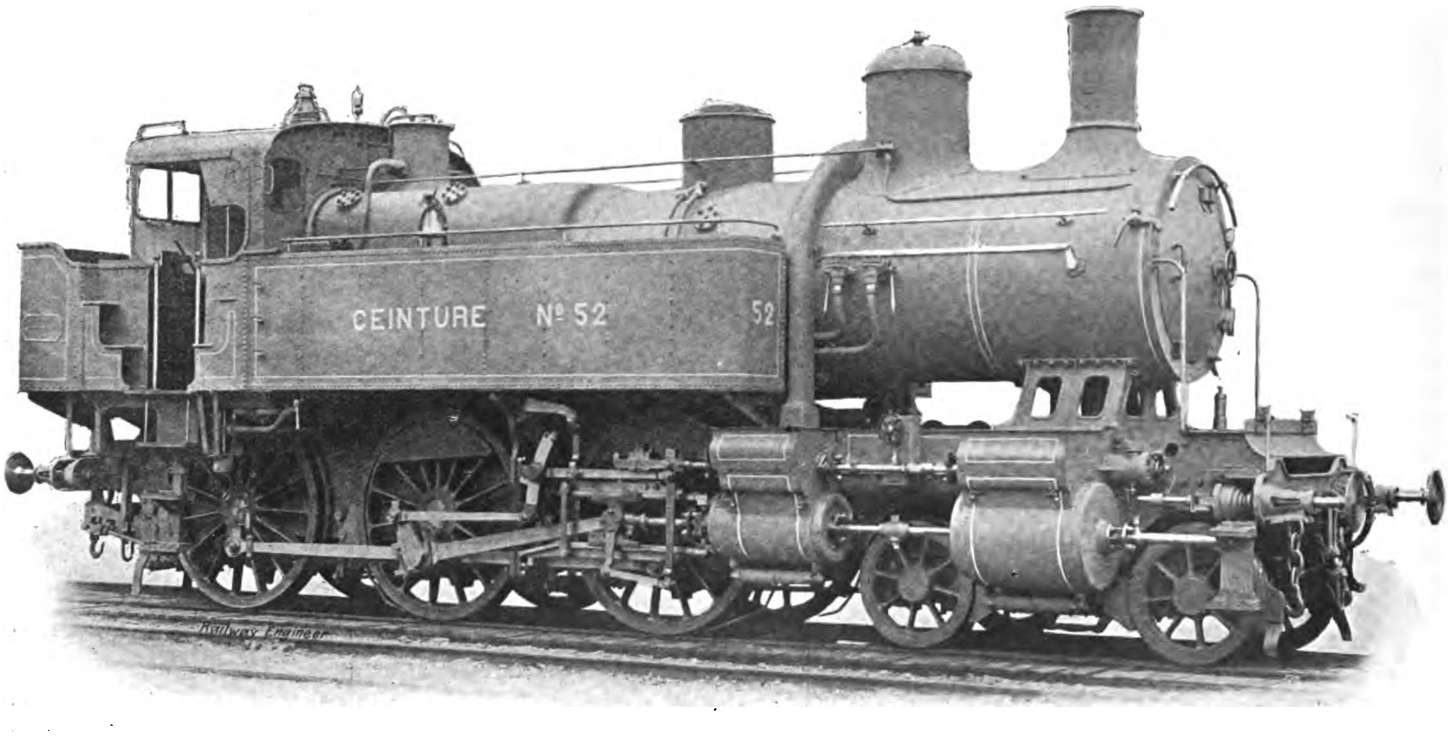


Fig. 1.

Compound Tank Engines in France.

THE idea of working suburban and other high acceleration trains making frequent stops is not usually associated with compound locomotives, in fact to such an extent has the contrary conception been accepted that it has come to be almost an article of faith among locomotive engineers, although the late Mr. F. W. Webb compounded one of the L. and North Western tank engines, and there are the un-

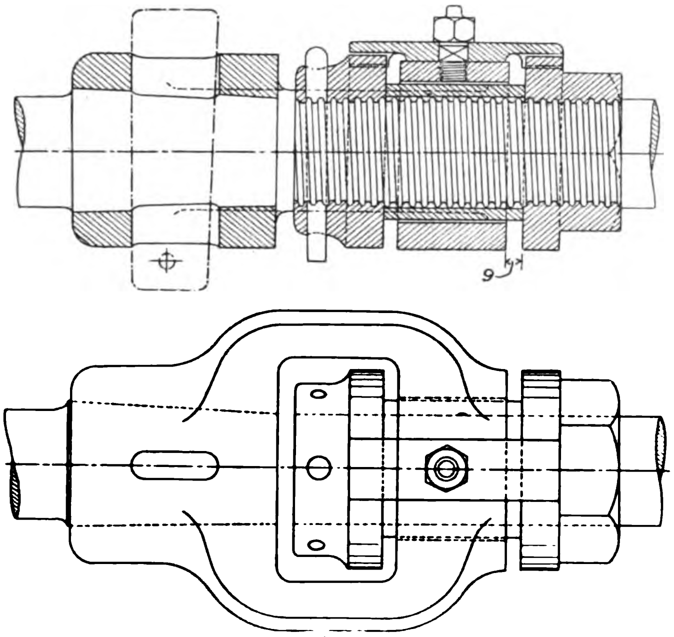


Fig. 2.

doubtedly successful 2-cylinder compound tank engines working on the Belfast and County Down R., and also on what was the Belfast and Northern Counties R. (now part of the Midland R.).

However, it is to the Continental lines that we must turn to find other and more recent examples, and especially to France, where some very powerful types have within the last few years been put into service.

schemed to meet a greatly reduced schedule which had been decided upon. They are 10-wheeled 6-coupled engines, with a leading 4-wheeled bogie and four compound cylinders, each pair of high and low pressure cylinders being arranged tandem-wise, from which it will be seen that the design is one of uncommon interest.

Following on the above-mentioned engines, the Eastern R. of France brought out another type of compound tank engine, also designed for dealing with fast suburban trains. In this design, while four cylinders are used they are not

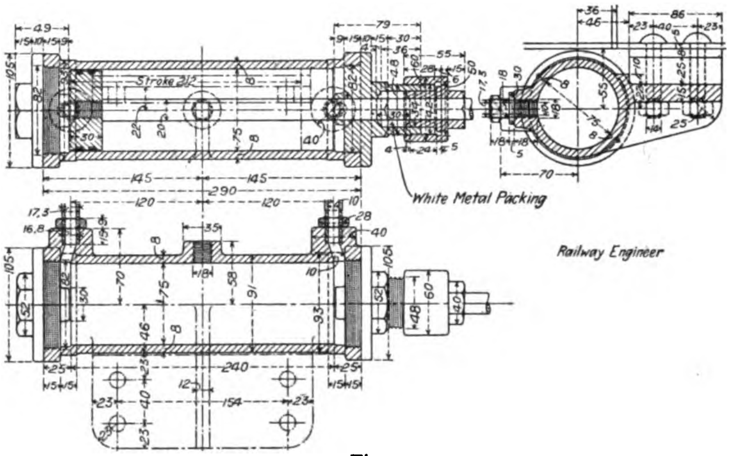


Fig. 4.

arranged in tandem but have a pair of inside and a pair of outside cylinders, each pair driving a different axle. The engines have 14 wheels, six being coupled and a four-wheeled bogie at each end.

In addition to these two types, which are passenger train engines, there is another and interesting type which has recently been introduced on *La Grande Ceinture* of Paris for hauling heavy goods trains at high speeds and with frequent stops. These engines have eight coupled wheels and a 4-wheeled bogie at the leading end; four cylinders arranged in a similar manner to the engines of the Eastern R. of France.

Referring to the engines for the *Petite Ceinture*, which

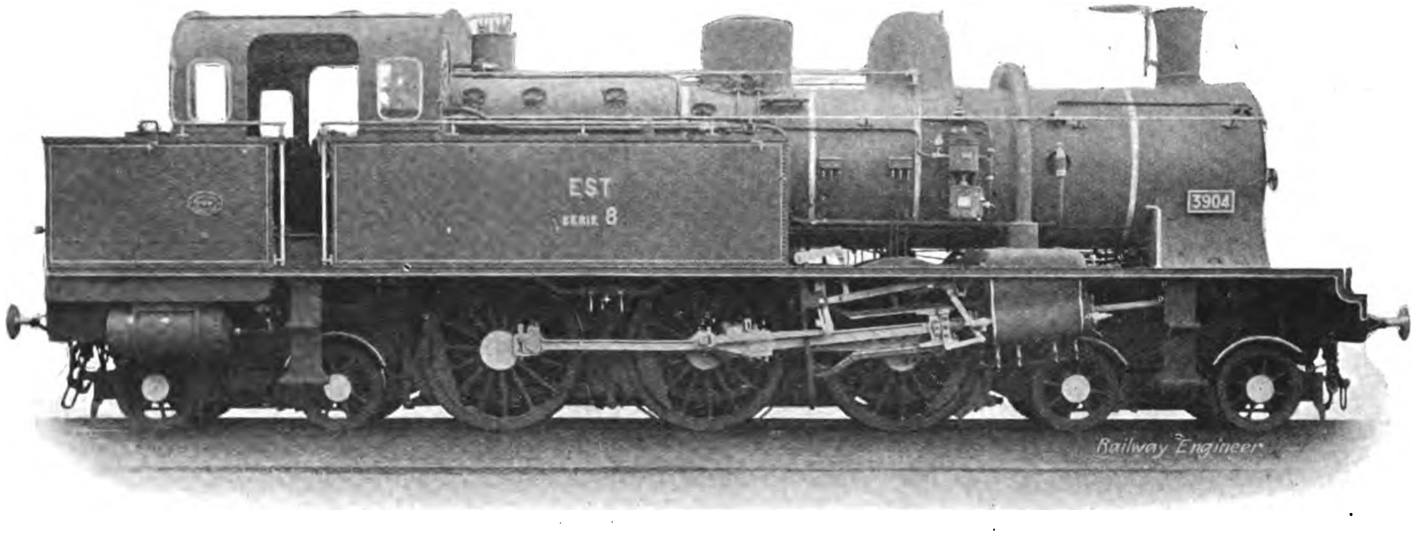


Fig. 3.

It may fairly be said that the recent multiplication of tank engines having compound cylinders is due to the success which has attended the design of engines brought out for *La Petite Ceinture* by the technical department of the Northern R. of France. These engines were especially

are illustrated by fig. 1 (see page 184), they were designed after many experiments had been made with various types of locomotives, the results being in favour of the compound system. The adoption of the tandem arrangement of the cylinders was decided

upon with a view to eliminating the weight of the two additional sets of valve gears commonly used in France in connection with four cylindered compound engines, because the weight of the engines was limited to 16·2 tons per axle; a further reason was to obtain the accessibility of outside cylinders only.

The arrangement of the cylinders is as follows: The h.p.

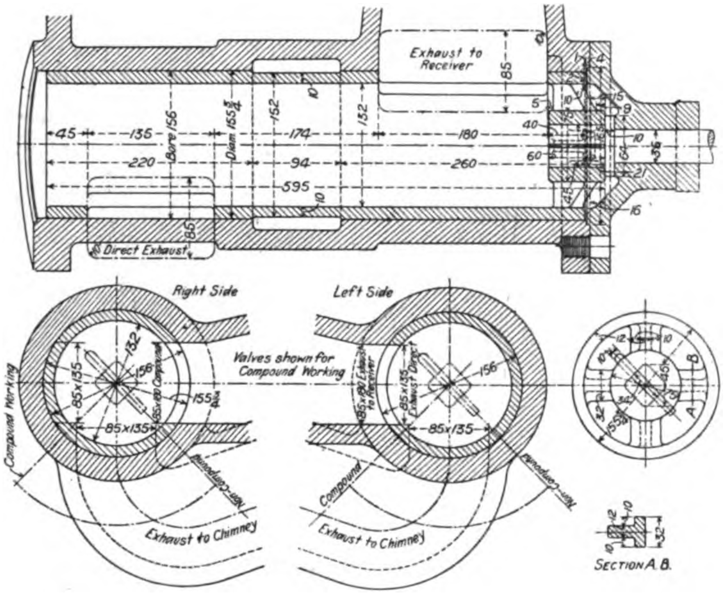


Fig. 5.

are placed immediately in front of the coupled axles with the l.p. ahead, and between the bogie wheels. The exhaust from the h.p. cylinders flows direct to the steam chest of the l.p. through rotating intercepting valves, these latter valves also acting as starting valves, being automatically moved by a small air motor which is set in motion when the regulator is placed in full open position, so that live steam at the reduced

head uniting to two is of a special design which permits of a certain slip of 12 *m.m.* when working; the lap of the l.p. valve is reduced to about one-half this play, the shock in "picking up" the l.p. spindle is very slight as the h.p. spindle is then rapidly approaching the end of its travel and is in consequence moving slowly; this crosshead is shown by fig. 2. With a cut-off of 40 per cent. in the h.p. cylinders it was found necessary to cut off in the l.p. at 60 per cent. Another effect of the slip of the crosshead is that the port opening of the l.p. cylinder lasts from 10 to 40 per cent. of the stroke instead of gradually closing.

The coupled wheels are 5ft. 9in. diam., the middle pair being the drivers; the bogie has wheels 2ft. 9in. diam., with a wheelbase of 6ft. 2·8in.; the rigid wheelbase is 13ft. 1·48in. All the wheels, including those of the bogie, are braked, so that rapid deceleration is obtainable.

The second engine referred to above, namely, that of the Eastern R., is illustrated by fig. 3. It possesses that important attribute of a well-designed local train engine, namely, equal facility of running in either direction, in fact these engines were especially constructed to eliminate the waste of time, etc., resulting from the use of engines which had to be turned in order to perform the return journey.

To render the task of driving the engine in either direction easier, the reversing gear and regulator are in duplicate, so that which way the driver is looking the wheel and lever is in front of him.

These engines are of great power and the four cylinders enable very smart starting to be made, especially as the intercepting valves are under the control of the driver and can be moved so as to allow live steam to enter the low pressure cylinders, which the high pressures are working independently. Details of the intercepting valves and the air motor for actuating the same are shown in figs. 4 and 5.

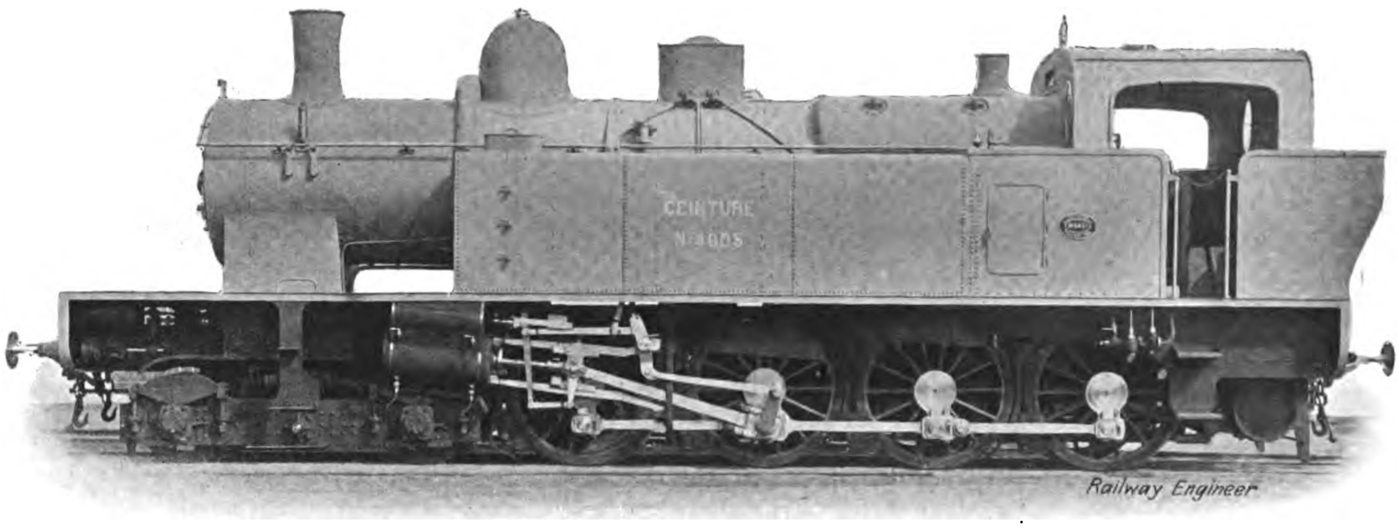


Fig. 6.

pressure of 85 pounds is admitted to the l.p. cylinders, at the same time the h.p. exhaust escapes direct to the atmosphere.

The valve gear is of the Walschaert's type, it is arranged to give a considerable difference of steam distribution in the high and low pressure cylinders; this is obtained by mounting both valves for each set of cylinders on two spindles which are so connected as to act as one, excepting that the cross-

The arrangement of the cylinders and motion possesses all the characteristic features of the well-known de Glehn system of compound engine, the h.p. cylinders being placed outside the frames and connected to the second pair of coupled wheels, while the l.p. cylinders drive the leading pair and are placed between the frames and under the smokebox; all four cylinders have piston valves, each of which is

actuated by a separate set of Walschaert's gear, also all the cylinders are inclined at an angle of 1 in 9.

As fairly high speeds have to be attained on the trains worked by these engines, the wheels are of moderate diameter, being 5ft. 2·2in., their springs are placed underneath the axle-boxes and are all connected on each side by compensating beams.

The bogies are duplicates one of another and are of the company's standard pattern, with inside frames; each axle-box has a separate spring placed above it; the wheels are 2ft. 9·4in. diam., the wheelbase is 5ft. 10·8in. The total wheelbase of the engine is 35ft. 5·2in., of which 12ft. 9·5in. is rigid.

The boiler is of the Belpaire pattern, working at a pressure of 227 lbs. per sq. inch; the fire-box is steeply inclined and placed over the rear coupled axle; the depth below the centre line of the boiler at the front and back is 4ft. 7·1in. and 2ft. 5·7in. respectively.

All the wheels of the engine are fitted with brake blocks, but as the brake gear on the bogies is self-contained it does not render them stiff when taking curves.

The last class is, as before mentioned, a series of powerful goods tank engines, which have been built for *La Grande Ceinture* of Paris for hauling very heavy goods traffic.

They are illustrated by fig. 6. The h.p. cylinders are placed outside the frames immediately in the front of the leading coupled wheels and inclined from the horizontal at an angle of 1 in 10; the l.p. cylinders are under the smoke-box and between the frames, and drive the leading coupled wheels; they are also inclined to an angle of 1 in 10.

Each of the four cylinders has a separate set of Walschaert's valve gear. The dimensions of the cylinders are, h.p. 14·56in. by 25·59in., l.p. 22·41in. by 25·59in. The intercepting valves are of a similar type to those used on the other two classes of engines described and permit of simple expansion working in all four cylinders at starting.

As in the majority of modern high pressure French locomotives, the boiler is of the Belpaire type, designed to work with a pressure of 227 lbs. per sq. inch.; the barrel is composed of two telescopic rings of $\frac{2}{3}\frac{1}{2}$in. plates; the mean diameter of the barrel is 4ft. 8·9in., the length between the tube plates being 13ft. 5·4in.; the firebox is placed over the last two coupled axles and has an inclined grate; the length outside the box is 8ft. 2·4in. The inside firebox is of copper plates, the stays of which are also of copper with the exception of the three top rows, which are of a special manganese bronze, an alloy which is reported to give very satisfactory results under the high temperature generated.

The coupled wheels are 4ft. 8·6in. diam.; the h.p. driving wheels have flangeless tyres to ease the engine on curves. The coupled wheelbase is 15ft. 6·9in., the total wheelbase being 27ft. 8·6in. The springs of the coupled wheels are all underneath the axle-boxes and connected in pairs on each side by compensating beams, the weight being very well distributed, as given in the table of dimensions annexed.

The bogie has outside frames and bearings; the springs are four in number, one to each axle-box, above which it is placed. The weight of the engine is transmitted to the bogie frame not by the centre, which acts purely as a pivot, but by two sliding pads, one placed on either side; the sliding side-play of the bogie is checked by long coil springs placed on either side of the centre. The wheels are 2ft. 7·4in. diam., placed 7ft. 2·6in. apart; the centre of the bogie is 8ft. 6·3in. in advance of the leading coupled wheels.

The principal dimensions of all three types of engines are stated in the following table :—

PRINCIPAL DIMENSIONS.

Railway	Petite Ceinture.	de l'Est.	Grande Ceinture.
Wheel Arrangement	4-6-0	4-6-4	4-8-0
Cylinders, high pressure	12·9 in. × 23·6 in.	13 7in. × 25·2in.	14·56in. × 25·59in.
,, low ,, ...	21·26in. × 23·6 in.	21·6in. × 25·2in.	22·44in. × 25·59in.
Wheels, diameter, coupled	5 ft. 9 in.	5 ft. 2·2in.	4 ft. 8·6in.
,, ,, bogie	2 ft. 9 in.	2 ft. 9·4in.	2 ft. 7·4in.
Wheelbox, total	25ft. 11in.	35ft. 5·2in.	27ft. 8·6in.
,, coupled	13ft. 1·4in.	12ft. 9·5·n.	15ft. 6·9in.
,, bogie	6 ft. 2·8in.	5 ft. 10·8in.	7 ft 2·6in.
Boiler, barrel, mean diam.	4 ft. 2·3in.	4 ft. 11·6in.	4 ft. 8·9in.
,, between tubeplates	11ft. × 5·8in.	13ft. 9·3in.	13ft. 5·4in.
,, firebox, length outside ...	—	8 ft. 10·8in.	8 ft 2·4in.
,, tubes, number	90 Serve	229	126 Serve
,, ,, outside diam.	2·75in.	1·9in.	2·75in.
,, heating surface, tubes ..	1,396 sq. ft.	1,449 sq. ft.	2,054 sq. ft.
,, ,, ,, firebox ...	108	150	123
,, ,, ,, total ...	1,504	1,599	2,177
,, grate area	24	27·6	24·4
,, working pressure	227 lbs.	227 lbs.	227 lbs.
Tank capacity	1,100 gallons	2,100 gallons	1,323 gallons
Bunker ,, ...	3 tons	3 tons	4 tons
Weight, full bogie, lbs.	—	44,922 lbs.	44,312 lbs.
,, 1st coupled axle, lbs. ...	—	33,829 ,,	31,966 ,,
,, 2nd ,, ,, lbs. ...	—	34,487 ,,	34,171 ,,
,, 3rd ,, ,, lbs. ...	—	35,759 ,,	33,730 ,,
,, 4th ,, ,, lbs. ...	—	—	34,832 ,,
,, hind bogie, lbs.	—	49,900 ,,	—
,, total lbs.	139,328 lbs.	198,897 ,,	179,011 ,,

the vacuum brakes which were used upon the trial trains and the Austrian State Railway generally. We are now able to illustrate the general arrangement of the brake equipment together with sections of the novel valves and diagrams showing their rapid and steady action.

It will be remembered that the trials were carried out to demonstrate the efficiency of the brake for trains of loose coupled goods wagons. The trains were of various lengths,

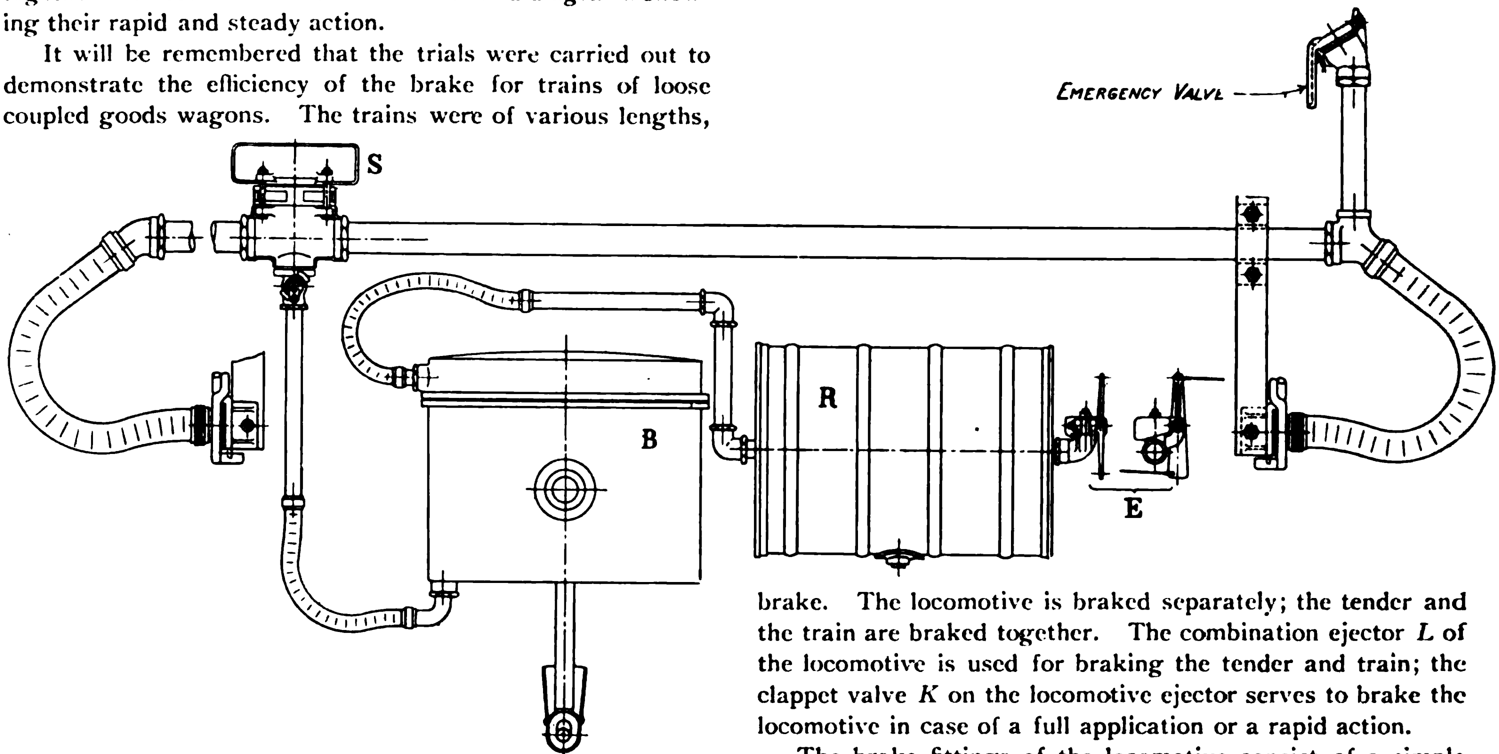


Fig. 2.—Equipment of Wagon.

the maximum number of vehicles being 75, some of which were fully loaded, some partly loaded, and others empty; some were fitted with brakes and others only piped. The wagons were marshalled in a variety of ways so as to represent as nearly as possible trains as they would be in ordinary service. All the stops were made without jerking or broken couplings and with a complete absence of "bunching" and derailment.

The brake equipment of the locomotive and tender is shown by fig. 1. It is the same as that of the passenger train brake. The locomotive is braked separately; the tender and the train are braked together. The combination ejector *L* of the locomotive is used for braking the tender and train; the clappet valve *K* on the locomotive ejector serves to brake the locomotive in case of a full application or a rapid action.

The brake fittings of the locomotive consist of a simple little ejector *l* connected with a steam pipe and with air pipes leading to the locomotive brake cylinders *B*, and to the clappet *K*. The air-piping runs to the front of the loco-

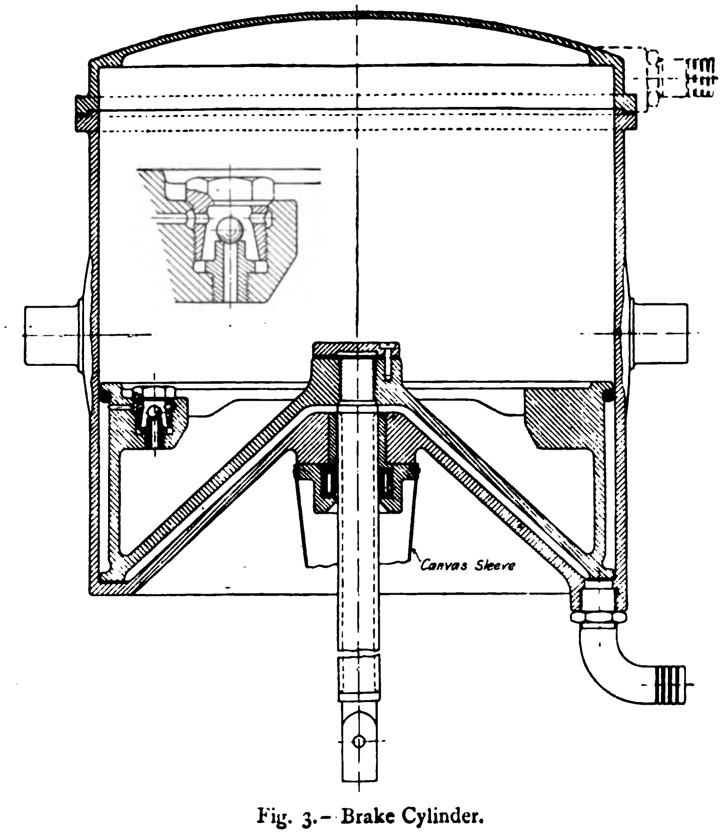


Fig. 3.—Brake Cylinder.

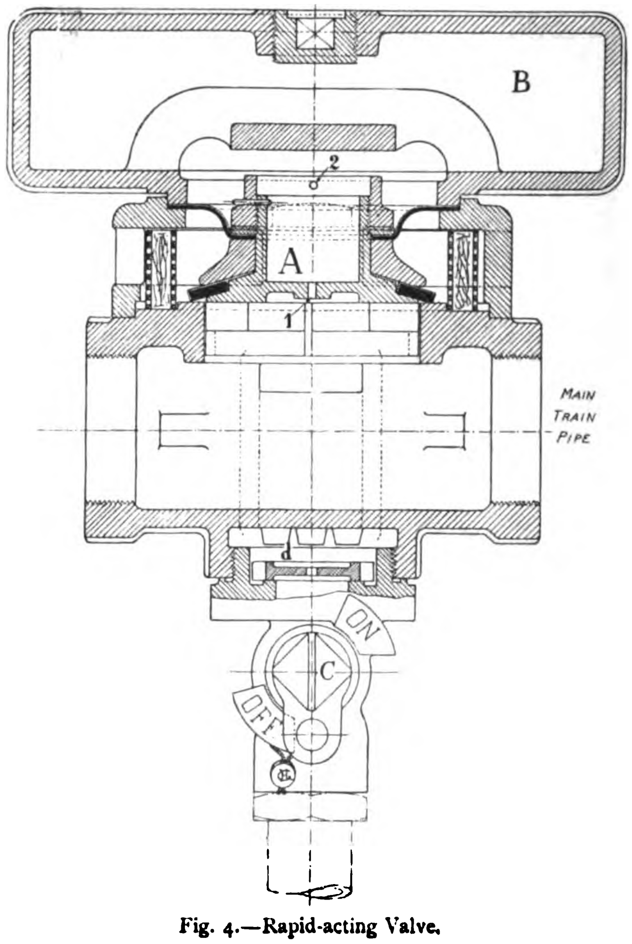


Fig. 4.—Rapid-acting Valve.

motive and to the back of the tender and is used to apply the brake from the pilot engine to both engines. The vacuum of the train brake attains 35 *cm* (13·7 ins.) and that of the locomotive brake 52 *cm* (20·47 ins.). A rapid-acting valve *S* is fitted on the main train-pipe leading to the front of the locomotive.

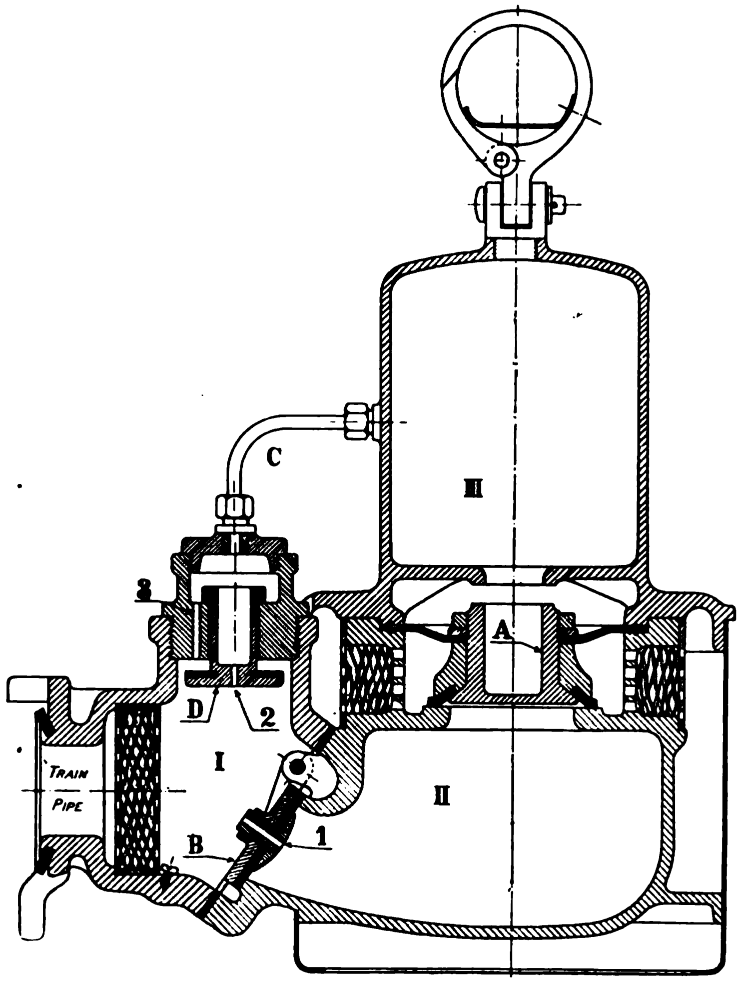


Fig. 5.—Portable Valve.

The brake equipment of the tender consists of one or two brake-cylinders *B*, with vacuum-chamber *R*, connected with the main train-pipe. On the main train-pipe is fitted a rapid-acting valve *S*, which, on the rapid action being applied, allows air to rush into the pipe for the space of about two seconds.

Fig. 2 shows the equipment for wagons. The main train-pipe is fitted with a rapid-acting valve *S*, fig. 4, which, in the event of a rapid application, allows air to enter the main pipe and cylinder. It, however, remains open only about one-third the time required by the brake-cylinder to attain its full brake power. Underneath this rapid-acting valve, fig. 4, there is a throttle valve and a cock connected with the piping which leads to the brake-cylinder.

To release the brake on wagons not coupled to the train a valve *E* is fitted on the vacuum-chamber or there are two valves, one on either side of the wagon connected with the vacuum-chamber by a pipe.

Wagons which are "piped" only have the train-pipe fitted with a "rapid-acting" valve. The emergency stop apparatus consists of a simple clappet valve connected by a vertical pipe with the main-train piping.

The Brake-cylinder is illustrated by fig. 3. Its main feature is that the ball-valve is fitted into the piston, whereas with the passenger brake it is on the bottom of the cylinder. This arrangement has the great advantage that directly the cylinder works the ball-valve is cut off by the rolling-ring from the main train-pipe and the tightness of the chamber does not depend on the tightness of the ball-valve. Moreover, with this type of brake-cylinder the connection, both with the main pipe and the vacuum-chamber, is effected in the simplest way possible.

The Rapid-acting Valve, fig. 4, consists of a valve *A*, a vacuum-chamber *B*, above it, and of a cast-iron casing, into which the main train-pipe is screwed. At the bottom of the valve *A* there is a hole 1 and another 2 at the side near the top. Underneath the casing is a throttle valve *d* with a small hole in its centre and the cock *C*.

The working of this valve is briefly as follows:—When the vacuum is created in the main train-pipe the chamber B is is also exhausted through hole 1. When a traffic application or a graduated application is made (the air slowly entering the main train-pipe) the vacuum, both below and above the valve *A*, is simultaneously and slowly reduced and the valve consequently does not act. But with a rapid action (allowing air to enter freely into the main train-pipe) the valve *A* is rapidly forced upwards, the vacuum in chamber B not being reduced so rapidly as in the main train-pipe, and it remains in this position until the air entering by hole 2 completely destroys the vacuum in chamber B, when the valve closes.

The most important feature of this arrangement of the Vacuum Brake is the Portable Valve, illustrated by figs. 5 and 6. It is coupled to the end of the main train-pipe on the last wagon, as seen in fig. 6.

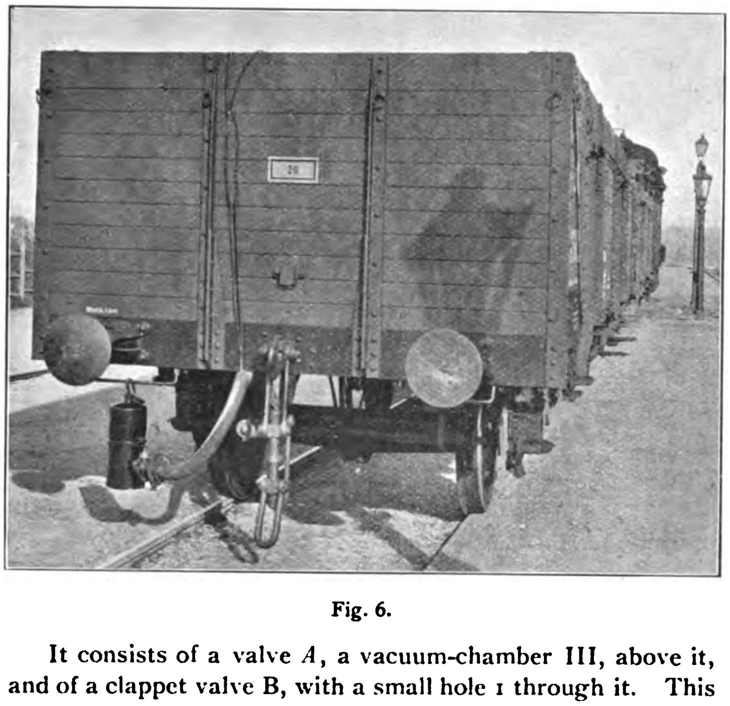


Fig. 6.

It consists of a valve *A*, a vacuum-chamber III, above it, and of a clappet valve B, with a small hole 1 through it. This clappet separates chamber I, which is in direct connection with the main train-pipe, from chamber II, under the valve. A small pipe *C* connects chamber I with chamber III. The valve *D*, which is also provided with a hole 2 in its centre, separates these two chambers, and there is another hole, 3, also, somewhat larger in the casing.

When the main train-pipe is exhausted the clappet *B* opens

and the chamber II and, through the holes 2 and 3, the chamber III. are also exhausted.

If a graduated application or a service application be made by means of the ejector on the locomotive (the air slowly entering the main train-pipe) the vacuum in the chambers II and III is simultaneously reduced by the air rushing through the holes 1, 2, and 3, and the valve *A* consequently does not work.

With a rapid application (air rushing into the main train-pipe) the valve *D* is rapidly forced upwards by the air entering chamber I, thus closing the hole 3. At the same time clappet *B* is also pressed on to its seat. The air consequently can only reach chamber II by passing through the hole I and the chamber III by passing through the hole 2. Chamber II being smaller than chamber III, the vacuum in the former is sooner destroyed than in the latter. Therefore, after a cer-

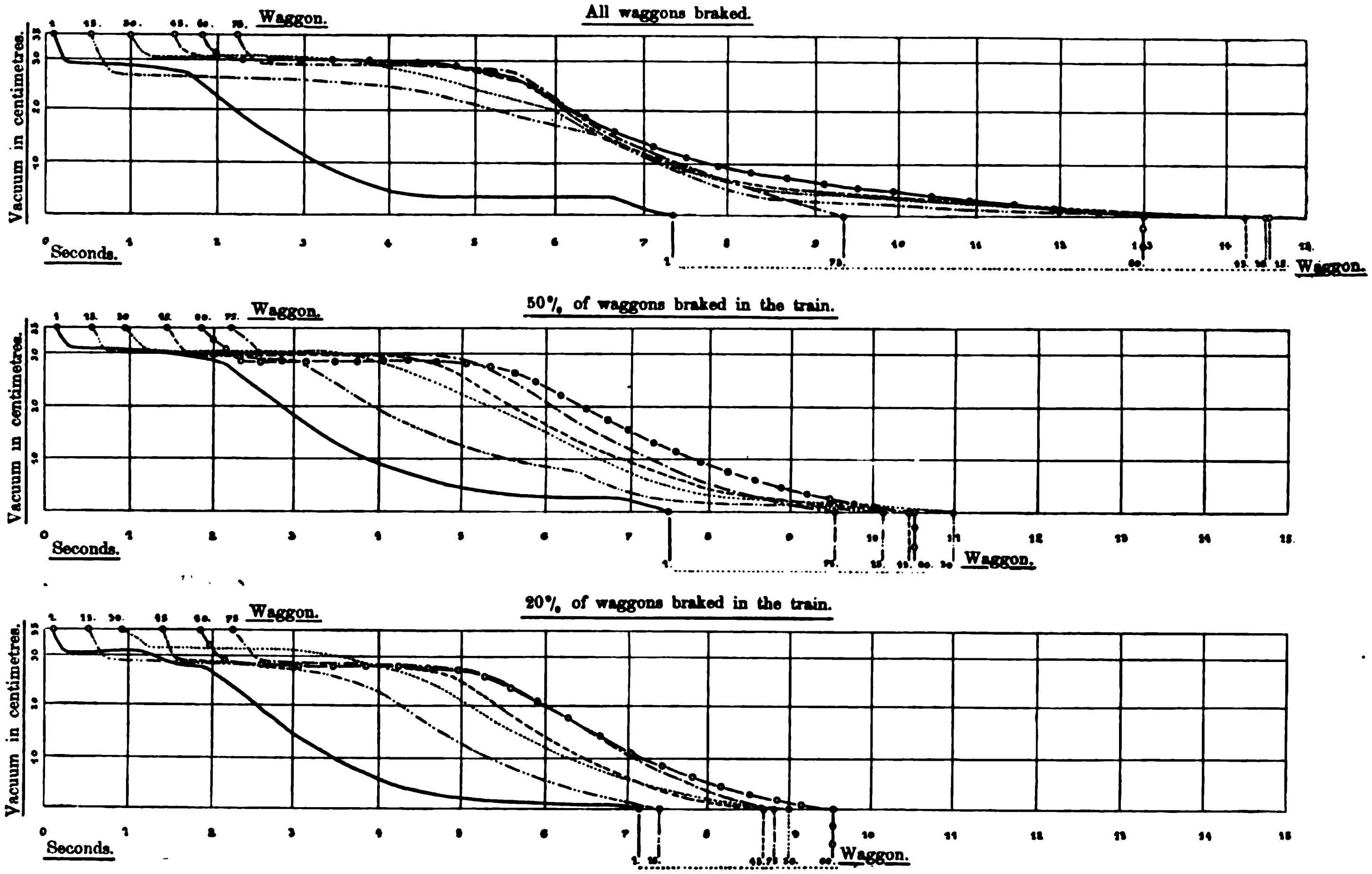


Diagram of Pressure on Brake Cylinder Pistons.

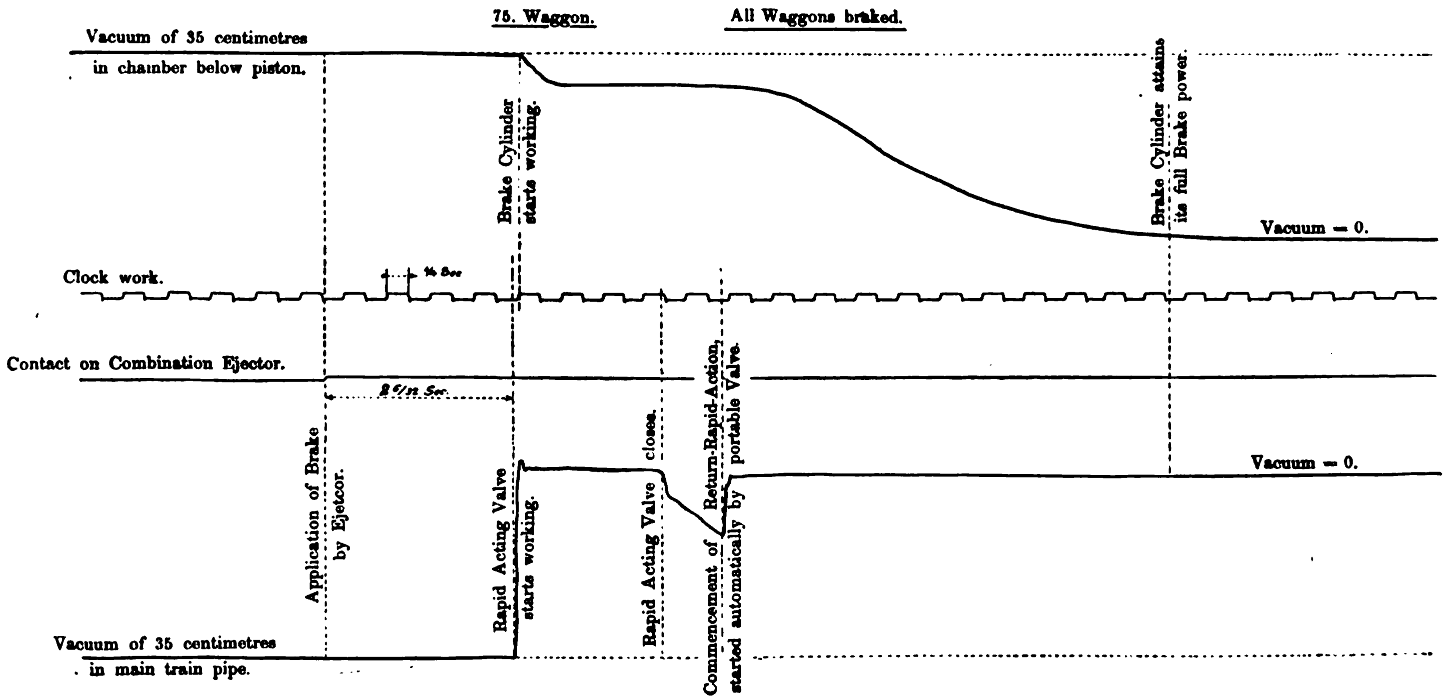


Diagram of Rapid-Action and Return-Rapid-Action.

Fig. 7.

tain time, the valve A opens and lets air rush into chamber II, which raises clappet B and, passing through chamber I, gets into the main train-pipe. Chambers II and III are so constructed that valve A opens shortly after the rapid-acting valves of the main train have closed. The vacuum under the piston of the brake-cylinder having been only partly destroyed, a reduced vacuum in all parts of the brake is created. The air freely entering the main train-pipe through the portable valve creates a second rapid action which, contrary to the rapid action made by the engine driver, acts from the rear towards the front of the train. Valve A remains open until the vacuum in the main train-pipe is completely destroyed. It is the action of this valve which prevents the crowding and bunching of the wagons, with the attendant evils of derailment and broken couplings.

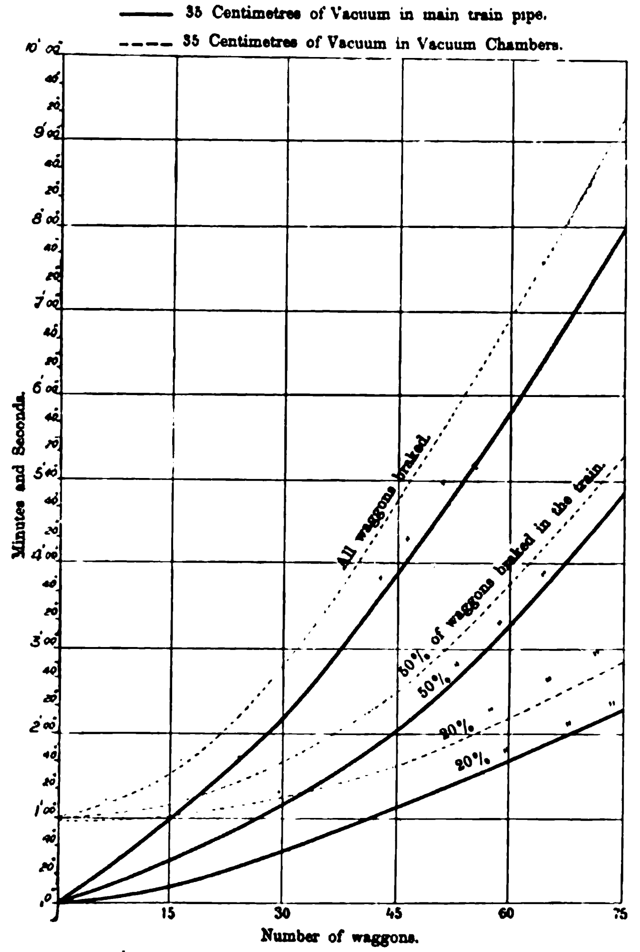


Fig. 8.—Time necessary to evacuate Brake Cylinders, Vacuum Chambers and Piping.

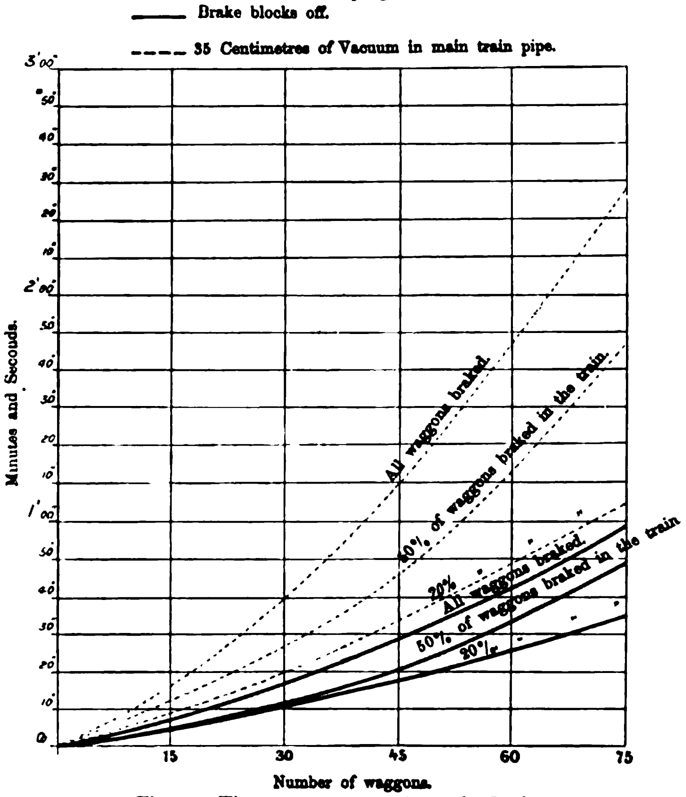


Fig. 9.—Time necessary to release the Brake.

In making service or graduated applications the handle of the combination ejector is brought slowly from the "Running Position" towards the position "Wagons Braked," more or less air entering the main train-pipe, according to the position of the handle; and this increases or reduces the brake power. The locomotive brake is not applied, but is held in readiness.

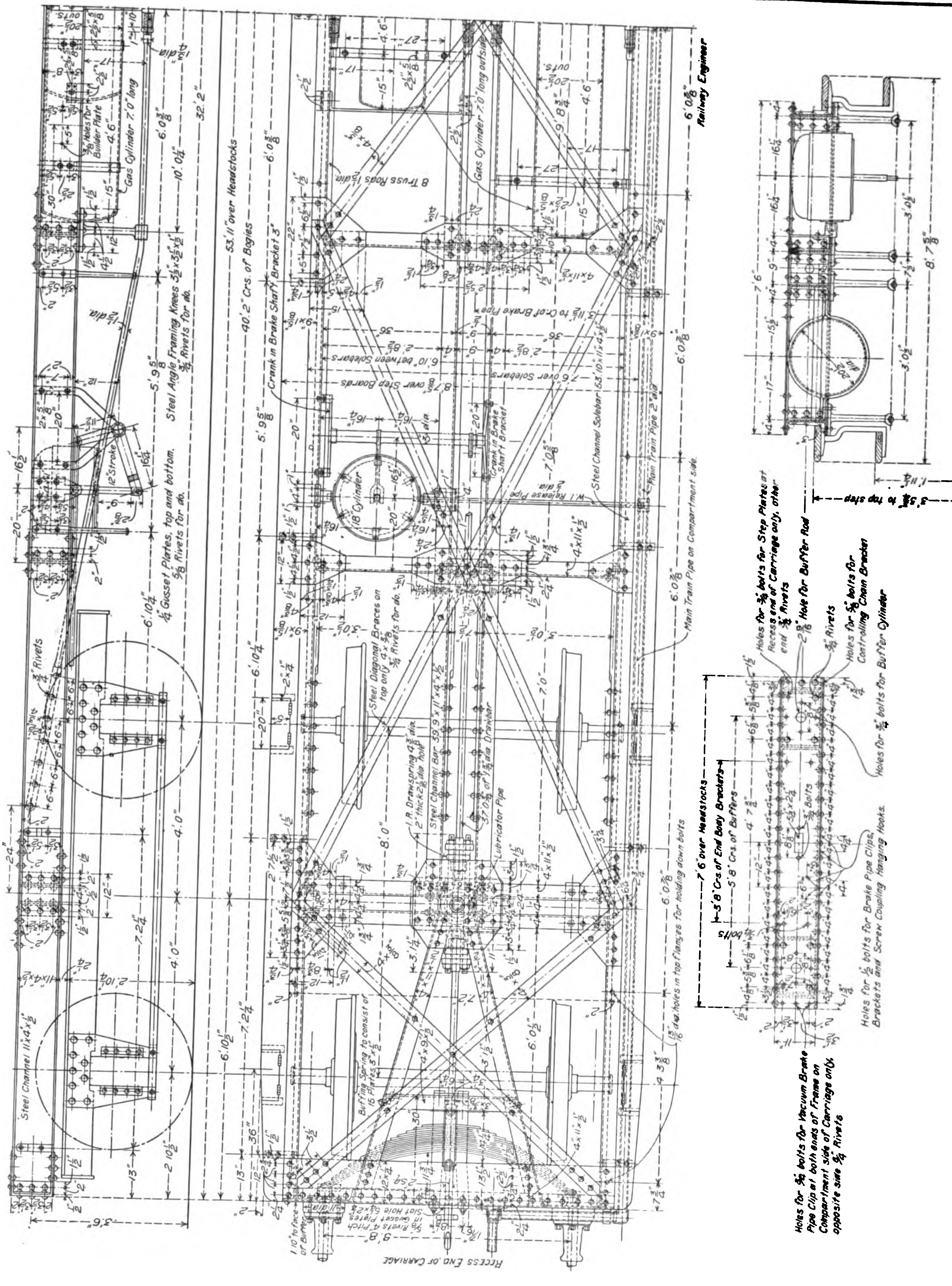
For a Rapid-action application the handle of the combination ejector is rapidly brought into position "On." The vacuum is suddenly reduced and the rapid-acting valves begin to act, giving a rapidity of brake action of 364 *m* (1,194 ft.) per second. As the rapid-acting valves open, the main train-pipe is quickly filled with air. These valves, however, closing before the vacuum below the cylinder piston is completely destroyed—the flat valve *d*, fig. 4, being in the way—a reduced vacuum is created in all parts of the brake and also in the rapid-acting valves, which are, consequently, again ready to work. The amount of this reduced vacuum depends on the number of vacuum-cylinders in the train.

At this moment the portable valve, fig. 5, opens suddenly, creating a rapid action from the rear towards the front of the train. The rapid-acting valves again close before the vacuum underneath the brake-cylinder pistons is fully destroyed, but the air continuing to enter the main train-pipe through the combination ejector and the portable valve, destroys it completely.

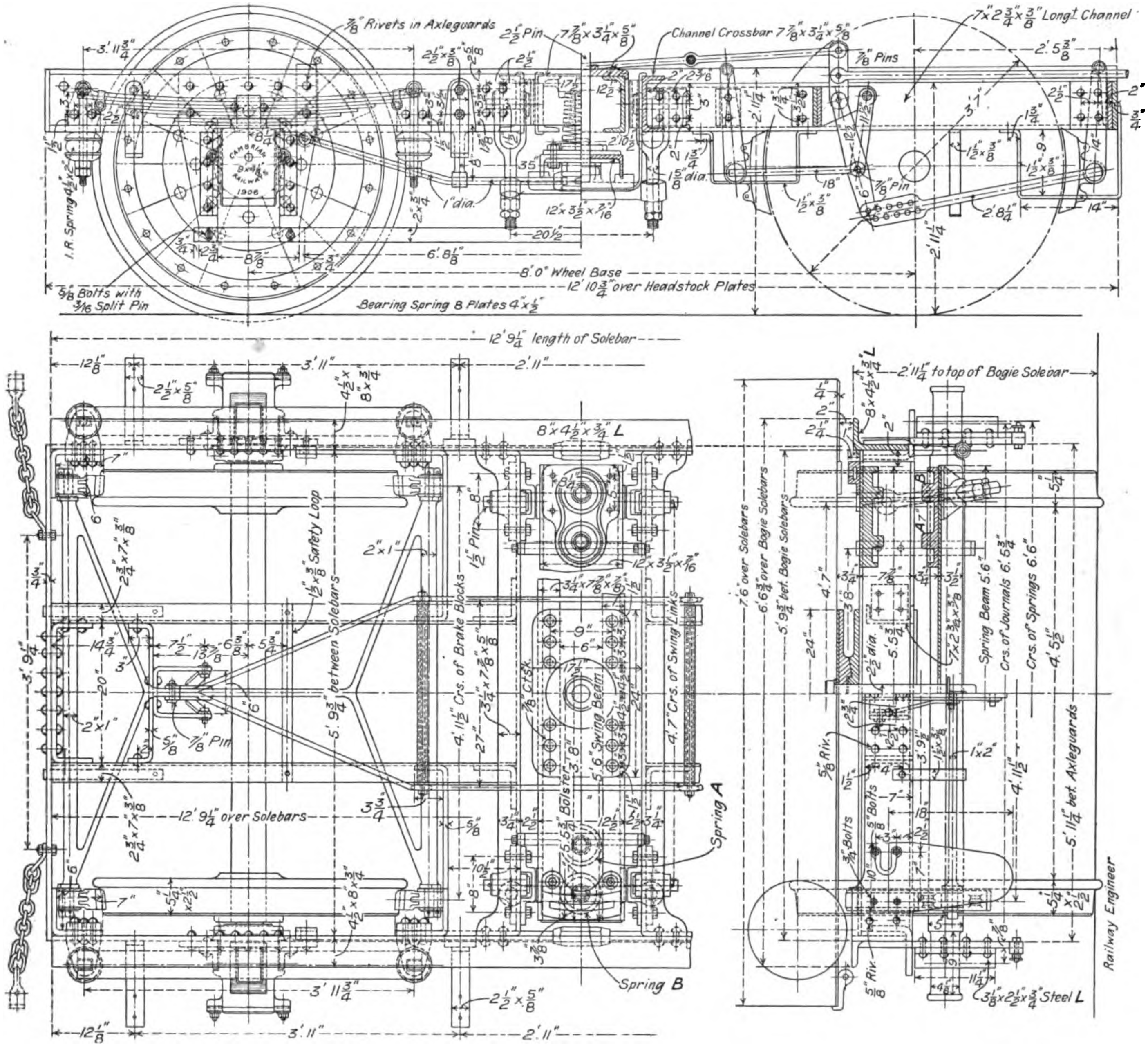
The diagrams on fig. 7 show the pressure on the brake-cylinder pistons of different wagons. The diagrams on fig. 8 give the time necessary to exhaust the brake-cylinders, vacuum-chambers, and piping; and those on fig. 9 the time required to release the brake.

3rd Class Corridor Carriages and Brakes; Cambrian Railways.

In our last issue we published drawings of the bodies of these carriages which were built at the company's works at Oswestry, to the designs of Mr. Herbert Jones, locomotive superintendent. We now give the drawings of the underframes and bogies, and which, being fully dimensioned, required but little description. It should, however, be noted that very few sections are used in the underframe; the sole-bars, longitudinals, diagonals, all the cross bearers and bogie centre bearers are all of steel channels 4 by 11 by $\frac{1}{2}$, connected by angles $3\frac{1}{2}$ by $3\frac{1}{2}$ by $\frac{1}{2}$, and covering or gusset plates top and bottom $\frac{1}{4}$in. thick; the bracing strips are 4 by $\frac{3}{8}$, so that there are practically only three sections in the underframe. This, of course, is a great advantage, especially in comparatively small works like those at Oswestry. The rivets connecting the angles to the members of the frame are $\frac{3}{4}$in. diameter, and for fixing the



Underframe for 3rd Class Corridor Carriages and Brakes; Cambrian Railways.



Bolster Bogie Springs { A $10\frac{1}{4}$in., Free. $8\frac{3}{4}$in., with load of 55cwt. $5\frac{3}{4}$in. dia. at base. $4\frac{3}{4}$in. dia. at top. $2\frac{3}{4}$in. dia. hole base. $1\frac{3}{4}$in. hole top.
B 9in. Free. $8\frac{3}{4}$in., with load of 10cwt. $5\frac{3}{4}$in. dia. at base. $4\frac{3}{4}$in. dia. at top. $2\frac{5}{8}$in. dia. hole base. $1\frac{3}{4}$in. hole top.

Bogie for 3rd Class Corridor Carriages and Brakes; Cambrian Railways.

gusset plates $\frac{5}{8}$in. diameter. The sole bars and longitudinals are each trussed with a queen truss 17in. deep, the tie-rods being $1\frac{1}{2}$in. ($1\frac{3}{4}$in. screwed ends) diameter, tightened by a right and left-hand threaded nut. The hangers for the vacuum automatic brake cyclinders and for the gas holders are shown. The draw-bar is continuous, and a plate spring is used for the draw and buffing gear. The bogies have the usual wheel base of 8ft., and their most noticeable feature is that the sole-bars, which are of angles 8 by $4\frac{1}{2}$ by $\frac{3}{4}$, are provided with a queen truss 8in. deep, the tie-rods being 1in. diameter, and adjustable by means of a right and left-hand threaded nut. Plate axle-guards (with angle wearing pieces), tied together by 2 by $\frac{3}{4}$ bars, are used. The ends of the sole-bars are connected by plates 7 by $\frac{3}{4}$ and strong bent plate knees. The fixed bolsters are of channels $3\frac{1}{4}$ by $7\frac{7}{8}$ by $\frac{5}{8}$, and the longitudinals of channels 7 by $2\frac{3}{4}$ by $\frac{3}{8}$. The swing bolster is made up of two channels $7\frac{7}{8}$ by $3\frac{1}{4}$ by $\frac{5}{8}$, backs outwards $12\frac{1}{2}$in. apart. The spring planks are of steel channels 12 by $3\frac{1}{2}$ by $\frac{7}{16}$—particulars of the bolster springs and also of the bearing springs are on the drawing.

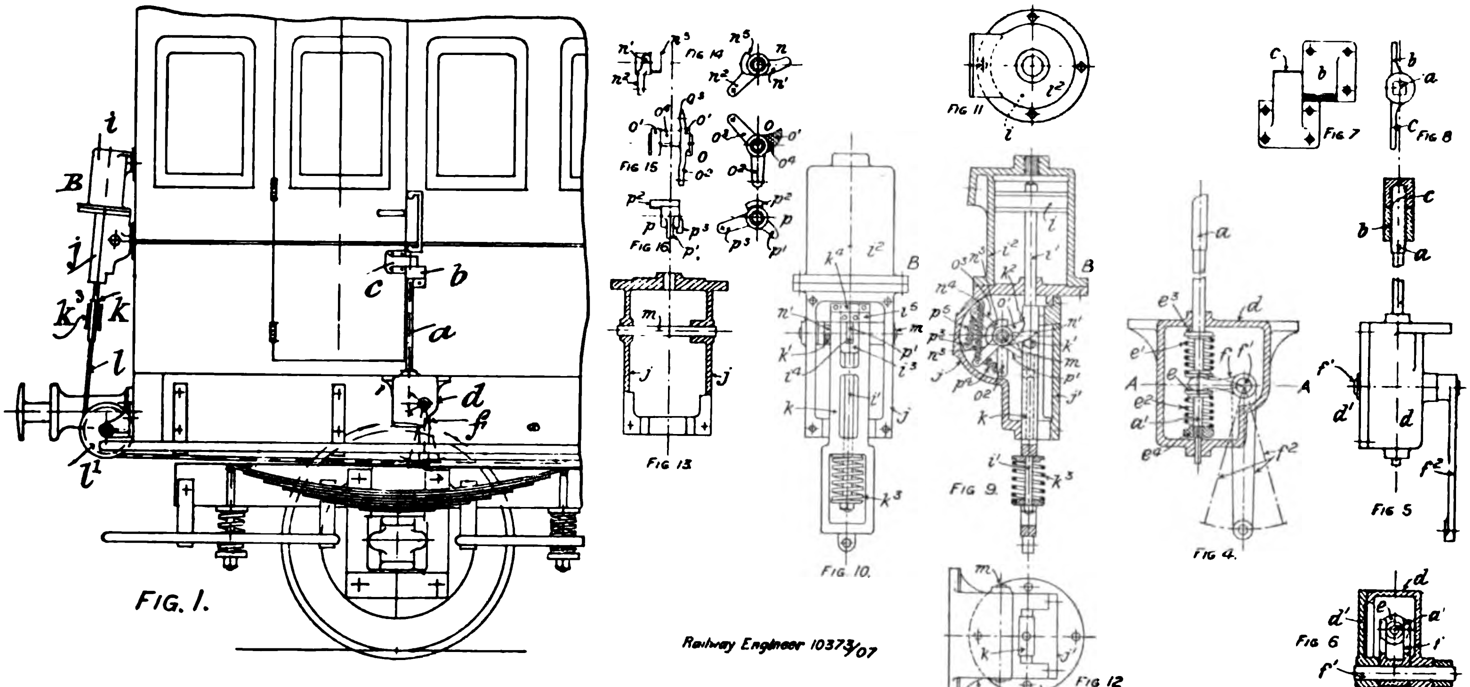
Double-brake blocks are fitted to each wheel, the arrangement of the rigging being also very clearly shown.

Recent Patents relating to Railways.

These abridgements of recently published specifications are specially compiled for this Review by Messrs. Wheatley and Mackenzie, Chartered Patent Agents, 40, Chancery Lane, W.C., from whom copies of the specifications can be obtained at an uniform price of 8*d*. each.

Door Locks (Carriage). *10,373. 4th May, 1907. F. B. Mounsey, 10, Sheaf Street, and E. Hall, Hawthorn Lea, Carleton, Poulton-le-Fylde, Lancashire.*
This invention has reference to door locking and unlocking arrangements under the control of the driver or guard of a train. Sliding bolts *a* serve as locks and engage the bottom part of the door. Each bolt *a* works in connection with springs so arranged as to permit a door to be shut or closed

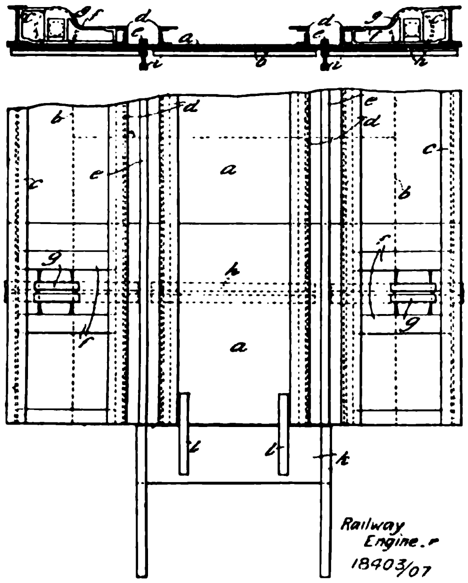
after locking has been effected, and also to allow the other bolts to act readily and without strain should one or more bolts stick or be held. A convenient way is to pass the extremity a^1 of each sliding bolt a through a box d, with removable cover d^1, and to arrange a collar e on each bolt shank, such collar being backed up by a spiral spring e^1, e^2, one on each side. With each collar e the fork of a bell-crank lever f, pivotted on a stud or shaft f^4 to the box d or elsewhere, engages, and the long arm f^2 of each of such bell-crank levers hang pendant behind the foot-board and well out of the way. All the long arms of the levers on either side of a coach are coupled together either by a long connecting rod g or other tie, so that all levers move in unison. The presence of one spring in connection with each bolt shank a^1 allows the bolt to yield by compression of the spring and so allow of a door being shut even after locking has been effected, whilst the other spring allows any particular lever to move in unison with the others even if its bolt be held fast momentarily or otherwise for any reason. The collar e is loose on the shank a^1 and the springs e^1 e^2 are confined between its extremities, and the collars e^3 e^4, as fig. 4 clearly indicates. A sprng h anchored at h^1 and attached to or in connection with each connecting rod g holds the bell-crank levers f in such a position as to keep the bolts off. To bring the sliding bolts a into action, the connecting rod g must be reciprocated and held against the action of the spring h until such time as release is to take place, and this is done by utilising a vacuum apparatus, or by means of fluid pressure acting on a piston so as to have a motive power at instant command. At the end of each side of a coach is mounted a cylinder and piston apparatus controlled to hold-in or set the locking bolts, or to release same. This cylinder and piston apparatus may vary considerably so long as it serves to hold the connecting rod or tie or move same into the locking position and to quickly release same. In one construction of mechanism for this purpose a cylinder and piston arrangement B is employed, the piston i, and consequently its rod i^1, being shifted by atmospheric pressure when a vacuum is created from time to time, or power applied behind the piston in the cylinder i^2. In connection with such piston rod i^1, and disposed in a suitable casing j, is a slide bar or sliding block k capable of being locked or held when required, the real function of which is to hold the connecting rod g against the spring h and so keep all the bolts a locked, and yet be ready for quick release. This sliding bar or block k may surround the piston rod i^1 and also the slotted head i^3, or be otherwise disposed, and a flexible tie l passing around a grooved pulley l^1 may couple the sliding bar or block k to the connecting rod g. Working in connection with the sliding bar or block k and piston rod i^1 are levers or catches, preferably three in number, and all conveniently mounted on a common stud, shaft or spindle m. One



of these levers or catches, n, is a setting lever. The second lever, o, is the locking lever for the sliding bar or block k. The third lever is the releasing lever p. The setting lever has a shaped arm n^1 acted on by a projection k^1 on the sliding bar or block k, and a tail-piece n^2 connected by a spring n^3 to a fixed point n^4 of the casing j. It has also a tooth or abutment n^5. The function of this setting lever is to set the releasing lever, *i.e.*, move it back and hold it clear of the sliding bar or block k during the first advance. The locking lever o has two connected teeth or projections o^1 o^1, which engage recesses or notches k^2 k^2 in the back of k, the locking lever o likewise having two tail pieces or lever arms o^2 o^3. The function of this locking lever is to hold or lock the sliding bar or block k on completion of the first advance. The releasing lever p has a nose p^1, and also a tooth or abutment p^2 and a single tail-piece p^3, between which, and the lever arms o^2 o^3, springs p^4 p^5 extend. The main function of the lever p is to effect release of the sliding bar or block k by acting on lever o. (*Accepted 20th February, 1908.*)

Surface Traversers. *18,403. 14th August, 1907. F. W. S. Stokes, of Messrs. Ransomes and Rapier, Ltd., 32, Victoria Street, London.*

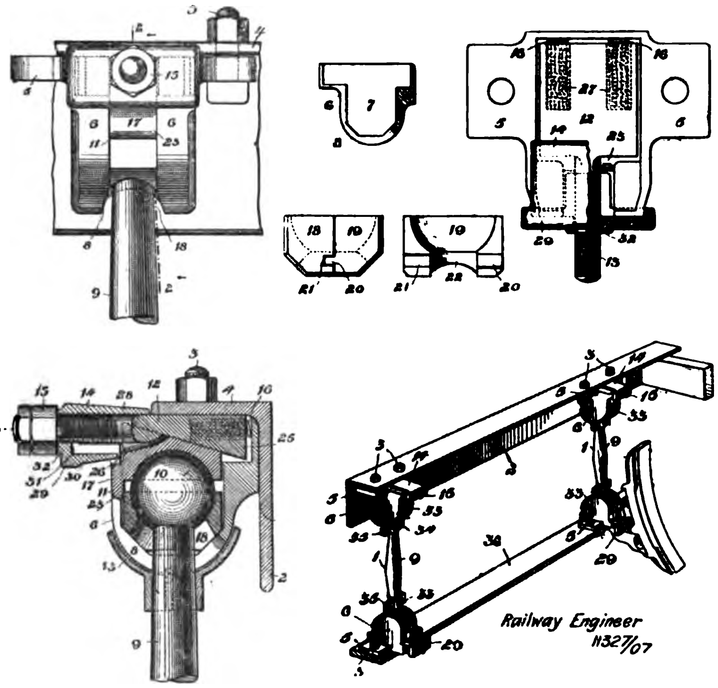
A traverser constructed according to this invention comprises cross plates a forming a platform, which may be regarded as constituting very wide cross girders and by the use of which the depth required for construction is considerably reduced. These plates are enabled to carry the load by longitudinal distributing girders c d fixed to the upper surface of the plates, some of them at the sides of the platform and others between these and in proximity to the rails on the traverser, but so that they do not contribute at all to the distance through which the rolling stock has to be lifted. The reactions produced by the loads supported by the rails e are distributed by the girders nearer the rails and are collected again by the outer longitudinal girders and passed by them to the travelling wheels. Short transverse girders f connecting the girders c with the outer girders of the pairs d, serve to carry the traverser wheels g spaced at suitable distances apart along the traverser. These wheels are preferably mounted on roller bearings and have annular grooves



in them which engage a longitudinal rib on the surface of the traverser rails *h*, so as to avoid the necessity for flanges to the wheels with the consequent cutting through of the track rails *i*. (*Accepted 27th February, 1908.*)

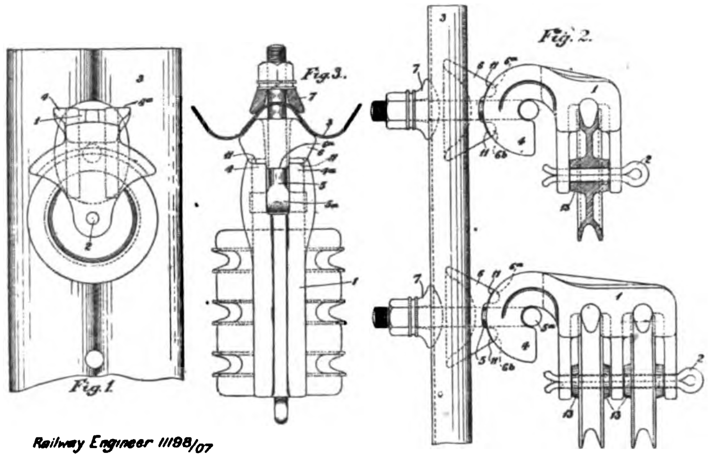
Brake Hanger. *11,327. 15th May, 1907. J. A. Brill, Woodland Avenue, Philadelphia, U.S.A.*

In order to support and secure the brake in its proper position relative to the wheels and to readily adjust for wear of the moving parts, the hanger is formed of rods 9 with balls 10 at their ends resting in adjustable sockets 11, which in turn rest in casings 6 attached to the transom and brake beam. Each socket 11 is held against its ball by a wedge 12, which has a bolt 13 that passes through the cap 14 and is held in position by means of nuts 15 and springs 16. The socket 11 is divided into an upper section 17 and a lower section 18. The lower section 18 is composed of two identical parts, and each part is provided with a recess, spherical-shaped to fit the ball 10, and a tongue 20 and a groove 21, which are conveniently placed, so that the parts 18 will conveniently fit together, the tongue 20 of one part entering the groove 21 of the other. The lower portion of the recess 19 adjoins the flared opening 22, which is adapted to receive and surround, but not fit, the rod 9. The exterior of the section section 17 rests on top of the ball 10 and is supported thereby a short distance from the lower section 18. The section 17 has a lip 23, which rests in the slot 8 and slightly overlaps the upper corner of the section 18. The upper edge 24 of the section 17 is given an inclined form with a plane surface, which is adapted to fit and engage a similar inclined plane surface 25 on the wedge 12. The wedge 12 is provided with cylindrical holes or recesses, in which rest springs 16, which also rest against the walls of the casing 6, and tend to force the wedge-surfaces 24 and 25 into intimate contact. (*Accepted 27th February, 1908.*)



Pulleys for Signal Wires. *11,198. 14th May, 1907. T. E. Haywood, The Bungalow, Tunnel Hill, Worcester, and McKenzie and Holland, Ltd., Vulcan Iron Works, Worcester.*

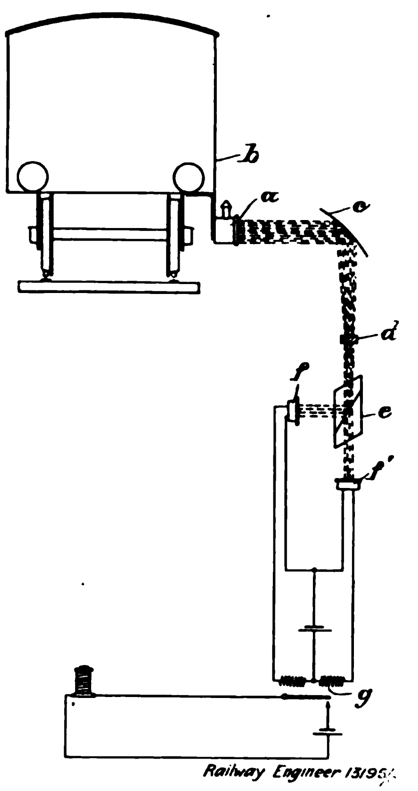
These pulleys are intended for carrying wires either in a straight line or on a curve, the pulley carrier and pulleys being adjustable to various angles to suit various curves on which the wires may have to run. For this purpose the pulley carrier 1 is provided at the inner end with a pair of curved hooks 4 4^a, which rest against a seating block 6, and a T bolt 5 is passed between the hooks and through the block 6 into the stake 3. The block 6 is formed so as to fit into a recess or corrugation in the stake 3, so that it will not turn



upon the bolt 5, and the upper and lower centre parts 6^a, 6^b of this block or casting 6 project between the hooks 4, 4^a so as to prevent lateral displacement or turning of the pulley frame or carrier 1 on or with the bolt 5. The bolt 5 is provided with a suitable washer 7 whose inner surface is shaped so as to conform to the contour of the stake 3, and a nut is also provided on the bolt 5, which when tightened up binds the T-head 5^a of the bolt tightly in the rounded recess, against the inner edges, of the hooks 4, 4^a, and thus hold the pulley frame securely to the stake 3 either in a horizontal position or at an angle as may be desired. (*Accepted 27th February, 1908.*)

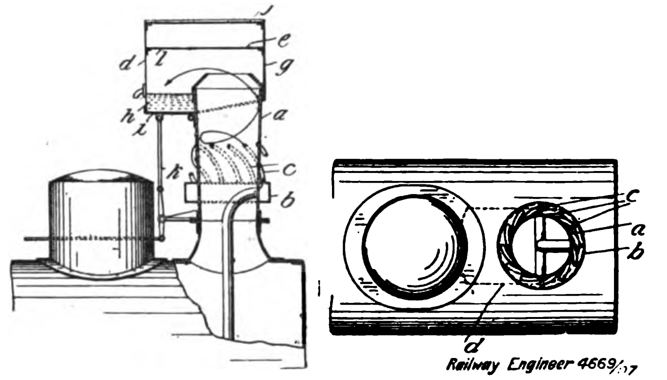
Signalling System. *13,195. 6th June, 1907. The British Thomson-Houston Co., Ltd., 83, Cannon Street, London. (A communication from the Allgemeine Elektricitäts-Gesellschaft, Friedrich Karl-Ufer 2-4, Berlin.)*

According to this invention polarised light is utilised to act upon selenium so as to cause a signalling device to be operated, the system being rendered insensitive to ordinary light. An illuminating device *a* is carried by the moving vehicle *b*, from which only polarised light emanates. Arranged adjacent the track is a concave mirror *c* adapted to receive the rays of polarised light and reflect them through a double concave lens *d* upon a Nicol's prism *e*. The double concave lens *d* is employed to convert the convergent rays of light into parallel rays before entering the Nicol's prism. Arranged in close proximity to the Nicol's prism are two selenium cells *f* and f^1 of approximately equal resistances, and these cells are arranged in circuit with a differential relay *g*. When the concave reflector *c* transmits unpolarised light to



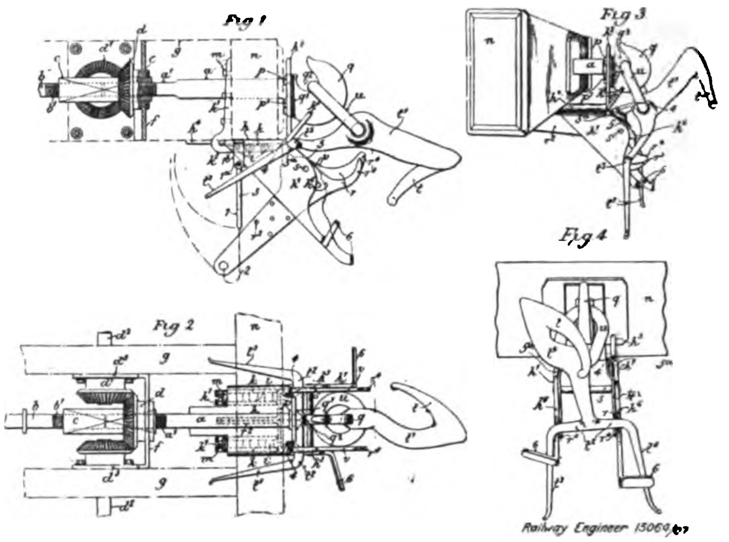
the Nicol's prism this light is split into two parts of equal intensity; one passing directly through the prism falls upon one selenium cell, and the other part, being reflected at right angles, falls upon the second selenium cell. In this way the resistances in the relay circuits are maintained approximately equal, and the relay system is balanced. But when polarised light is reflected on to the Nicol's prism it either passes right through or is totally reflected on to one or the other of the cells, according to the direction of polarisation, so that the relay system becomes unbalanced and the differential relay relay operates to close or open a signal circuit in the known manner. (*Accepted 20th February, 1908.*)

Spark Arrester. *4,669. 26th February, 1907. M. Woitzuck, 48 Georgenkirchstrasse, Berlin, Germany.*
The lower part of the funnel *a* is surrounded by the annular chamber *b*, into which the exhaust steam is conducted. From the chamber *b* distributing pipes *c* run into the funnel in such a manner that the various steam currents flowing out of them ascend with circular movements along the side of the funnel. On the top of the funnel a cylindrical hood *d* is



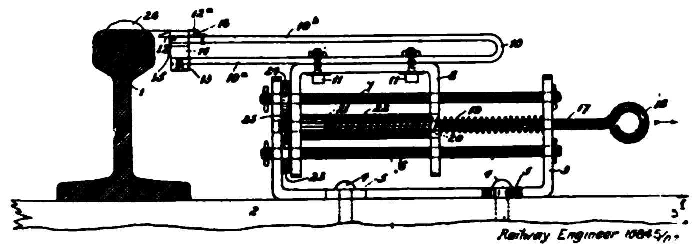
arranged which supports a wire-netting *e* and above the same a fine mesh netting *f*. The front of the cylindrical hood is provided with sieve-like perforations *g*, whilst on the opposite side the hood is eccentrically enlarged to form a receiver *h*. The bottom *i* of this receiver can be lowered from the cab of the locomotive. (*Accepted 20th February, 1908.*)

Couplings. *13,064. 5th June, 1907. T. A. Brockelbank, 35, Queen Victoria Street, London.*
This coupling is of that type in which a bent coupling hook such as *t* suspended from the draw hook *q* is operated by a pivotted lever *r* connected with a transverse rock shaft 1^a having hand levers 3 at both sides of the vehicle. In order to enable a coupling of this type to be tightened up, the draw hook *q*, lever *r* and bracket h^2 are so mounted as to be capable of being moved backwards and forwards. In order to effect this movement the draw bar is made in two parts connected by a nut *c* with right and left hand screw threads, and bevel gear *d* d^1 isprovided for rotating the nut, capable



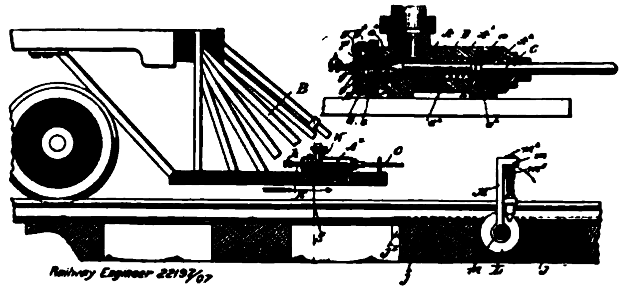
of being worked from either side of the vehicle. The bracket or carrier h^1 is connected with the draw bar so as to move with it by a plate h^2. (*Accepted 13th February, 1908.*)

Fog Signalling Apparatus. *10,845. 9th May, 1907. H. F. Clayton, "Craigmhor," Huddersfield.*
This apparatus is intended for placing detonators on the rail and removing them without the fogman approaching the rail, and comprises a detonator holder 10 formed of a bent metal strip with upper and lower members 10^a 10^b, and a



slide 8 mounted on guide rods 6, 7 carried on a frame 3 bolted to the sleeper. An operating rod 17 is attached to the usual counterbalance lever of the semaphore signal, by which the detonator may be withdrawn from the rail, a spring 19 being provided for returning the detonator to the rail when the operating connection is released. (*Accepted 13th February, 1908.*)

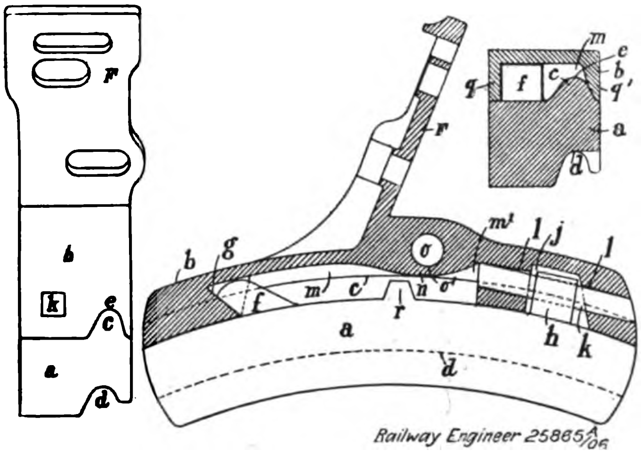
Safety Appliance for Air Brakes. *22,197. 8th October, 1907. Date claimed under Patents Act, 1901—24th October, 1906. W. H. Winks, 404, Randolph Street, Baltimore, U.S.A.*
This invention provides a device for automatically applying the air brakes of a train should the latter approach an undetected closed signal, or improperly placed points. For this purpose a casing A is connected with the train pipe and has one end closed by a protected frangible plate E. Through the other end of the casing a rod C is adapted to slide, being normally held a short distance from the plate E by a spring D, but capable of being moved inwards to break the plate E by a tripping lever M, which is operated by the signal or



switch to which it corresponds. (*Accepted 20th February, 1908.*)

Brake Blocks. 25,865A. *15th May, 1907. P. McCullough and W. Vaux, 14 and 16, Taylor Street, Liverpool.*

This invention relates to brake shoes with detachable wearing parts which can be readily replaced when worn through. The holder *b*, in which the detachable part *a* is secured by a claw *f* and key or wedge *k* passing through holes *l* in the holder and a hole in the lug h, has a recess *m* to enable the detachable part *a* or shoe proper to have a longitudinal move-



ment given to it when being applied or removed. In the part *n* not hollowed out is located the hanger hole *o*, which can thus be brought into closer proximity to the shoe than has hitherto been possible with a brake block of this type. The part *n* touches, or is in close proximity to, the rear of the grooved flange *c* of the shoe, and the front edge o^1 of the hanger hole *o* is only three-eighths of an inch or thereabouts from the grooved flange *c* of the shoe, and the extremities of the claw *f* and lug *h* are actually at the rear of the edge o^1. The thickness of the holder is thus reduced to a minimum, and the thickness of the shoe is correspondingly increased. (*Accepted 20th February, 1908.*)

COMPLETE SPECIFICATIONS ACCEPTED.

1906.

25865a. Brake blocks for tramway and railway rolling stock. McCullough and Vaux.

1907.

4669. Spark arresters and extinguishers for locomotive engines and the like. Woitzuck.
6252. Railway chair and key. Daw and Daw.
6861. Locking of railway carriage doors. Parry.
9264. Automatic fastener for railway-carriage doors. Pendlebury.
9925. Railway signalling. Warren, Blades and Wren.
10058. Method of audible railway signalling. Lacey.
10373. Locking and unlocking of railway carriage doors. Mounsey and Hall.
10845. Fog signalling on railways and apparatus therefor. Clayton.
11198. Pulleys for carrying signal wires. Haywood and McKenzie and Holland, Ltd.
11327. Brake supporter for railroad cars. Barker.
13064. Coupling apparatus for railway vehicles. Brocklebank.
13195. Signalling systems for railways and the like. British Thomson-Houston Co.
13323. Moving machine for treating without removal railway or other rail deformities. Woods and Gilbert.
14333. Automatic coupling for railway and like vehicles. Donaldson.
15887. Locomotives. Bothwell.
16365. Air brake, lighting and signalling system. Mayo and Houleman.
17583. Grooved wheels for mono-railway and tramway systems. Kearney.
18403. Surface traversers for use on railways and tramways. Stokes.
19558. Electrical locking apparatus for railway signalling. Siemens Bros. and Co.
19849. Couplings for controlling rods of brakes between railway and other vehicles. Reid.
22197. Safety appliances for air brakes. Winks.
26073. Securing railway carriage doors. Brooking.
26622. Railway signal and point mechanism. Cumont and Compagnie de Signaux Electriques Pour Chemins de Fer.
28713. Railway sleepers and means for attaching rails thereto. Roberts.

1908.

556. Metallic railway sleepers and means for securing railway rails thereto. Toy.

Locomotive Journals and Bearings.—IV.*

Great Central Railway.

THE engines of this Company have to make long runs, as trains of all descriptions are often run through from Grimsby or Liverpool to Marylebone, and there are regular services of non-stop express trains between London and Sheffield, and all engines have to be designed to negotiate the Woodhead bank, which is about mid-way between Manchester and Sheffield, and is pretty much the same in either direction, viz., 1 in 126 average for 20 miles. The main lines have besides numbers of sharp curves.

The designs which Mr. J. G. Robinson, M.Inst.C.E., the chief mechanical engineer, finds suitable for such work are illustrated below.

Driving Axle Box, fig. 17.—This box has several distinctive features and details. It is made of wrought-iron and faced on the wheel side with a gun-metal plate $\frac{5}{16}$in. thick fixed on with $\frac{3}{8}$in. brass countersunk screws. It is $12\frac{1}{2}$in. wide between the horns and $8\frac{1}{2}$in. high above the centre, the wearing surfaces on the horns being $6\frac{5}{8}$in. by $16\frac{3}{4}$in. and the flanges 1in. wide. The axle box carries a dead weight of $7\frac{1}{4}$ tons. The oil channels on the sides next to the horns are shown on the drawing.

The Bearing fits into the box which is machined out square with a flat seat, the corners being removed as shown. It is prevented from moving laterally by an annular ring ($6\frac{1}{4}$in. outside and $4\frac{1}{2}$in. inside diam.) which fits into a recess turned out for it in the top of the box to a depth of $\frac{1}{8}$in. The

*Previous articles of this series appeared in February, March and May, 1908.

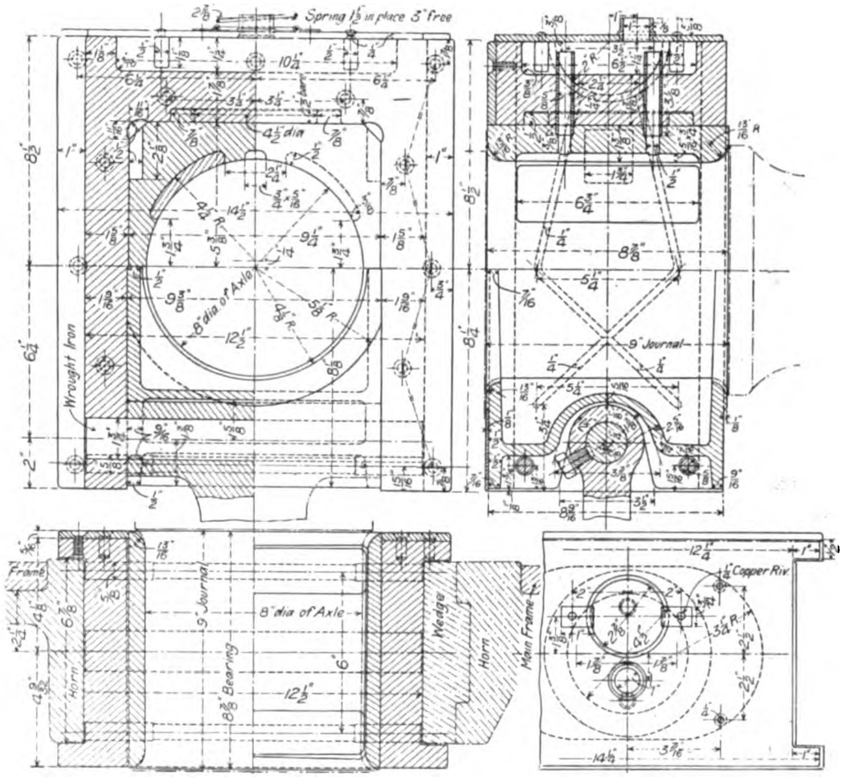
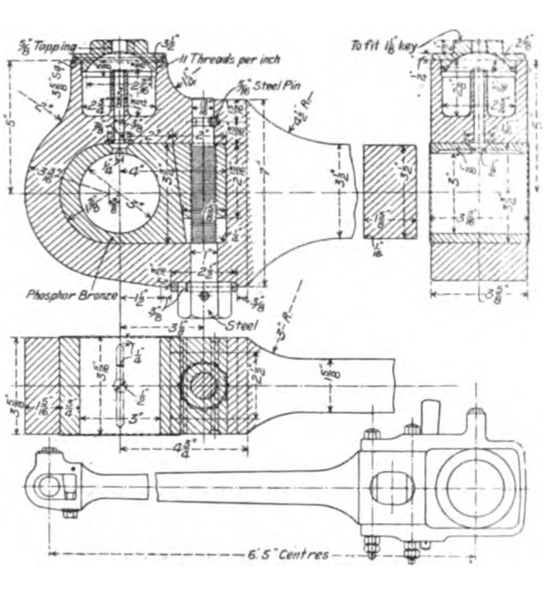


Fig. 17.—Driving Axle Box; Great Central Railway.

bearing is $8\frac{3}{8}$in. long for a journal 8in. diam. by 9in. long. It has two white metal insets about 3in. by $6\frac{3}{4}$in. long.

The Keep is made out of cast-iron. Its sides are carried up to meet the sides of the bearing. It rests on the T-head (which is the full width of the inside of the box) of the wrought-iron spring-link and upon two wrought-iron pins, $\frac{5}{8}$in. diam. The top of the box is cut out to form a large round-ended oil-well $10\frac{1}{4}$ by $6\frac{1}{2}$ by $1\frac{1}{4}$, and from this the



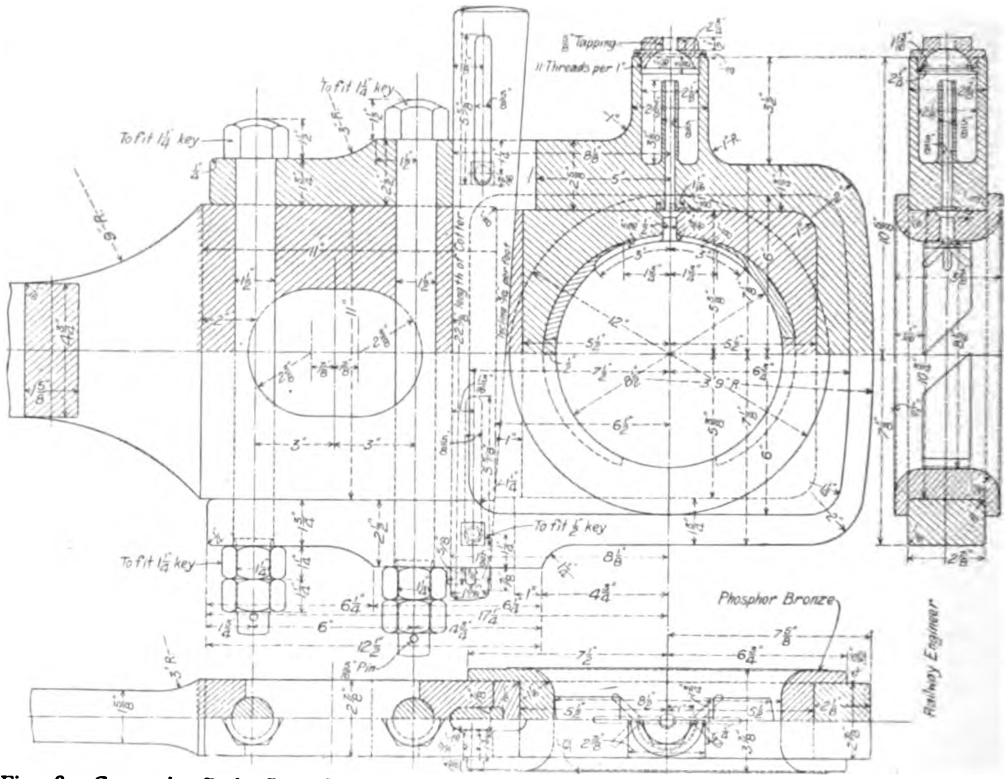


Fig. 18.—Connecting Rod; Great Central Railway.

oil is syphoned by trimmings down two $\frac{3}{8}$in. wrought-iron pipes (which are extended to enter the gun-metal bearing to a depth of $\frac{3}{8}$in.) into an oil channel ($\frac{3}{4}$ by $\frac{5}{16}$ by $6\frac{3}{4}$) along the crown of the bearing. The oil is fed into the well through the brass nipple riveted into the cover from a lubricator on the splasher or frame plate.

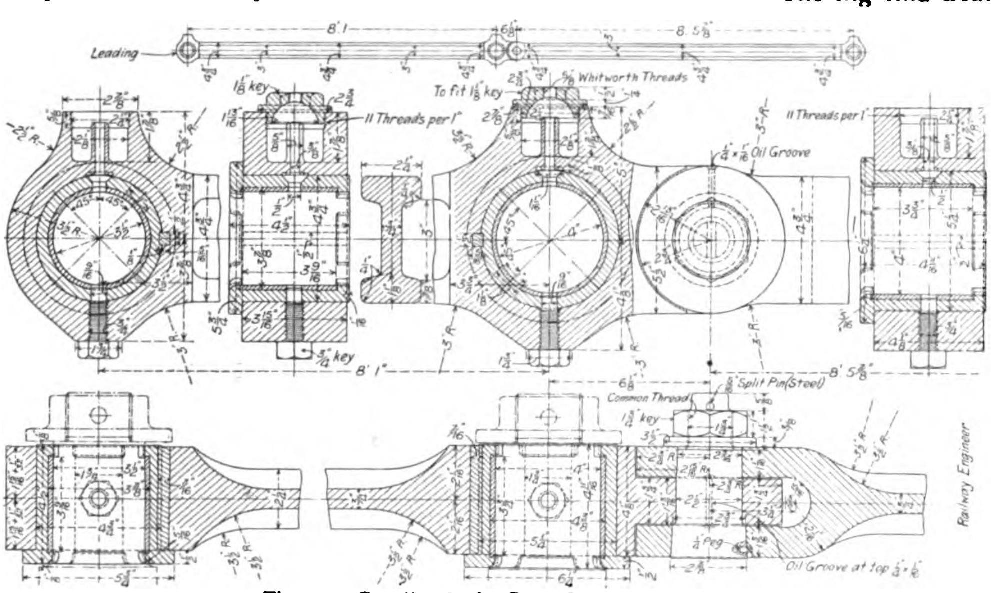


Fig. 19.—Coupling Rod; Great Central Railway.

The top of the box is closed by a steel plate $\frac{1}{4}$in. thick which is prevented from shifting by four studs ($\frac{1}{2}$ by $1\frac{1}{8}$) riveted to its under side and which fit against the sides of the oil-well. The cover is also provided with a coiled spring $2\frac{1}{8}$ in diam. of $\frac{5}{32}$ in. wire to prevent it rattling.

Connecting Rod, fig. 18.—This is the rod used on several classes of inside cylinder engines on the Great Central R. with cylinders up to 19in. by 26in. coupled wheels, 6ft. 9in. diam., and a working boiler pressure of 180lbs., and although it has a strapped big-end it yet differs in the design of the details from others of which we have published the drawings. The rod, which is 6ft. 5in. long between the centres, is made of mild steel. It is solid and tapers from $4\frac{3}{4}$in. by $1\frac{5}{8}$in. to $3\frac{1}{2}$in. by $1\frac{5}{8}$in., the corners being rounded off to a radius of $\frac{1}{16}$in.

The Big-End Bearing is $8\frac{1}{2}$in. diam. by $3\frac{7}{8}$in. long and is made of phosphor bronze with large white metal insets, arranged as shown, to take the thrust and pull. It is attached to the butt end of the rod by a square-ended wrought-iron strap having a middle section of $2\frac{1}{4}$in. by $2\frac{3}{4}$in. The strap is fastened by two wrought-iron bolts $1\frac{1}{2}$in. diam. provided with lock nuts and secured by a $\frac{5}{16}$in. split pin. The bearing is adjusted by means of a steel wedge (retained in place by the flanges of the bearing) and a tapered key prevented from slacking back by two steel $\frac{5}{8}$in. set screws and a split key. The butt end has a large lightening hole cut through it.

The Oil Cup is solid with the strap and is bored out to $2\frac{3}{4}$ in. diam. It is closed with a brass cap which has a filling hole through it tapped to receive a wooden plug or cork. The oil is syphoned by ordinary trimmings down a $\frac{3}{8}$in. feed hole to the oil channels cut in the bearing surface as shown on the drawing.

The Small-End is solid $3\frac{5}{8}$in. wide. It is fitted with a

phosphor bronze bush having a bearing 3in. diam. by $3\frac{11}{16}$in. long. The halves of the bush are adjusted by a steel wedge threaded on a steel bolt 1in. diam. which is fastened by a $\frac{5}{16}$in. steel pin rivetted through the rod and locked by a square iron washer which fits over the hexagonal head and into a recess cut for it in the end of the rod and secured by a $\frac{5}{16}$in. split pin.

The oil cup, which is larger than is generally provided on small-ends, is of the same pattern as that on the big-end.

Coupling Rods, fig. 19.—These rods are for 6-coupled goods engines with inside cylinders $18\frac{1}{2}$in. by 20in., wheels 5ft. 1in. diam., and 180 lbs. boiler pressure. They are made of forged steel machined to a flanged or I section, $4\frac{3}{4}$in. deep by $2\frac{1}{4}$in. wide parallel throughout, the web being $\frac{3}{4}$in. thick. The channels are 3in. deep and taper towards the web as shown; all the corners and fillets are $\frac{1}{4}$in. radius. The leading rods are 8ft. 1in. long between the centres, from the driving centre to the knuckle joint is $6\frac{1}{8}$in., and from the joint to the trailing centre is 8ft. $5\frac{7}{8}$in.

The driving pin journals are 4in. and the leading and trailing pin journals are $3\frac{1}{2}$in. diam., all being $4\frac{3}{4}$in. long.

All the Bearings are gun-metal bushes flanged at the inside ends—forced into the rod eye and further fixed with steel keys $\frac{1}{2}$in. by $\frac{7}{16}$in.; the driving bushes are $\frac{7}{16}$in. thick, and the others $\frac{3}{8}$in. They are all completely lined with white metal $\frac{3}{16}$in. thick except in four places, as shown on the drawing. The bushes and lining are further secured by $\frac{3}{4}$in. steel set screws put in from underneath. The lengths of the bearing are $4\frac{11}{16}$in. driving, $4\frac{1}{2}$in. leading, and $4\frac{3}{8}$in. trailing.

The oil cups are of precisely similar construction to those of the connecting rod.

The Knuckle Joint Pin is of steel. It is tapered in the jaws of the fork and prevented from turning by a $\frac{1}{4}$in. peg as shown, and secured with a washer and nut and $\frac{5}{16}$in. split pin. The bearing, which is not bushed, is $2\frac{1}{2}$in. diam. by $1\frac{3}{4}$in., the length between the jaws being $1\frac{13}{16}$in.

The coupling rods are retained in position by the usual flanged nut and tapered pin split at the small end.

(To be continued.)

Rust and its Prevention.*

PERHAPS in no branch of metallurgical science has a greater advance been made during the past few years than in that relating to the corrosion of iron and steel. That this phenomenon is worthy of even more attention than is now paid to it is, however, self-evident.

Not only has the structural and mechanical engineer reason to deplore the propensity to rust of iron and steel, but the metal merchant and warehouseman, the ironmonger, and even the householder welcomes with all too credulous eagerness the advent of every new rust-preventative.

Yet it is to the metallurgist or the chemist that we must look for a solution of the problem—if solution is to be found; no practical remedy can be effective which is not based upon firmly-proven-theory.

A review of the current theories on the formation of rust might not be without its advantages. The first to which we can attach any importance is that due to Crace Calvert, which was supported and extended by Prof. Crum Brown in a paper read before the Iron and Steel Institute in 1888. This theory, which, for the sake of distinction, may be called the "Chemical Theory," has stood, with only minor alterations and additions, until the present. It states that the essentials for the formation of rust are:—Iron and steel, oxygen, carbon dioxide, and liquid water (*not* water vapour).

Bi-carbonate of iron is formed during the reaction, but inter-acts with the oxygen of the air to form hydrated ferric oxide, $2Fe_2O_3 3H_2O$ (which is commonly known as rust), carbon dioxide and water. It will be gathered that, so far as the carbon dioxide and water are concerned, the action is cyclic; so that, given fresh supplies of oxygen and metallic surface, the action will continue indefinitely.

A practical result of this is that rusting action is very much more rapidly set up in interstices and crannies, or upon already rusted areas, where evaporation is slow, than upon smooth, plane surfaces. The resistivity to rust of a razor is mainly due to its relatively smooth surface, from which water (containing carbon dioxide) rapidly evaporates.

Calvert's theory has been to some extent modified by subsequent experiments, but Dr. Allerton S. Cushman, of the Department of Agriculture, Washington, D.C., led scientific thought into entirely new channels. In his paper on the electrolytic theory of corrosion of iron and steel, he has gathered together all the evidence which might cast doubt upon the chemical theory, supplemented it by brilliant original research; and added one of the finest contributions extant to the literature of rust.

Briefly, his theory asserts that rusting is mainly an electrolytic action promoted by irregularities in the metallic surface, and that the carbon dioxide and water, forming carbonic acid, tend to strengthen the electrolytic and facilitate the reaction. To enter into the details of his work would be out of place here, and those sufficiently interested should endeavour to gain access to the paper itself, or to some abstract from it. Apart from the numerous convincing proofs with which Dr. Cushman supports his assertions there are a variety of phenomena which tend to show that rusting is intimately connected with electricity. The fact that underground pipes in the vicinity of leaky electric cables tend to corrode much more rapidly than others; the greater liability to corrosion of magnetised steel; the encouragement of iron and steel to rust by the juxtaposition of metals electro-negative to iron, such as lead, tin, and copper—all these point to the existence of a very close relation between corrosion and electrical phenomena.

The establishment of an electro-motive-force between clean iron, and iron partially rusted, has been many times demonstrated, while a similar, but reversed action between clean iron and magnetic oxide of iron (smithy scale) has also been proved. In this latter case, the iron is electro-positive to the oxide, so that the effect of the action is very much more deleterious to the metal.

Mr. E. F. Law, in a paper on *Non-Metallic Impurities in Iron and Steel*, has drawn attention to this point, and suggests that it is from this cause that corrosion takes place very much more readily at a weld (where there is sure to be some magnetic oxide of iron) than elsewhere upon a piece of iron or steel.

Attention is also drawn in the same paper to the injurious effects of dissolved oxide in steel, and of particles of included slag upon resistivity to corrosion. All these remarks seem to point to the necessity of producing iron or steel as homogeneous as possible under the particular competitive circumstances which obtain. At least where resistivity to corrosion is of paramount importance, it cannot be too strongly urged upon buyers to buy *good* steel or iron, even though the price is a little higher than that of poorer qualities, since the latter, no matter how carefully both are protected with paints or other covering, is sure to have a shorter life than the former.

With regard to the relative ascendancy of one of the materials — wrought iron, cast iron, and steel — over the others as a rust-resister, much discussion has taken place. Of course cast iron with the "skin" on is a very much more resistant material than either of the others, but once this skin is removed it descends much to the level of the other

*Abstract of a paper read before the Birmingham University Metallurgical Society by M. Thornton-Murray.

two. Whether wrought iron or mild steel is the more resistant to corrosion is a very open question, probably depending upon the closeness and evenness of texture of the materials, though Professor Turner points out that for boilers and the plating of ships mild steel is slightly better than wrought iron with regard to rusting propensities, but that wrought iron possesses a small advantage over mild steel in ordinary atmospheric air.

If high-carbon-steels are more resistant to corrosion, it is probably because of their greater homogeneity, since no relation between carbon contents and resistivity to corrosion has been established.

Phosphorus and silicon generally tend to produce corrosion in steel and iron—indeed, the latter in high percentages (up to about 20) make a material very difficult to attack by even hot, strong acids. Manganese in steel, probably owing to its relatively irregular distribution, tends to promote corrosion, while nickel and other "special steel" alloying metals seem to make for greater resistivity.

These differences, however, are of little commercial importance, since, except for very special purposes, the insertion of these elements in proportions large enough to render the metal non-corrosive is quite impracticable. The engineer is forced therefore to record to the unsatisfactory expedient of applying an outer coat of protective material to his iron or steel.

Perhaps, in metals used in other than structural engineering, the most used, and most important, covering consists of some other metal. Tin plated goods are very widely used and sold, and it would not, perhaps, be inadvisable to deal with them here. To begin with, then, tin forms an excellent protective covering for a variety of purposes. The metal is malleable and adheres firmly to the iron or steel, so that a considerable amount of work may be applied to the tin plated article without stripping or cracking the covering metal. But tin is easily attacked by alkalies, and (here is its chief drawback) being electro-negative to iron it promotes corrosion rather than retards it, once an opening has been made in the covering and the tin and iron are exposed to the rusting action of wet and air.

For this reason zinc is an excellent covering, for it is electro-positive to iron, and tends to re-deposit on the iron if any electrolytic action is set up. But zinc is a brittle material, very liable to corrosion by acids, so that if an article is galvanized too thickly the covering metal will tend to scale off, while too thin a deposit is soon completely dissolved away by the atmospheric acids. In spite of these drawbacks, however, it is deservedly very largely used as a rust-preventative.

Electro-plating with copper, nickel, brass, and even silver and gold is, of course, very largely resorted to, and these metals form an excellent covering and give the article plated a good appearance, but against them all the same objection is to be urged: once broken through they rather aggravate than retard the corrosion of the metal which they are intended to protect, since they are all electro-negative to iron.

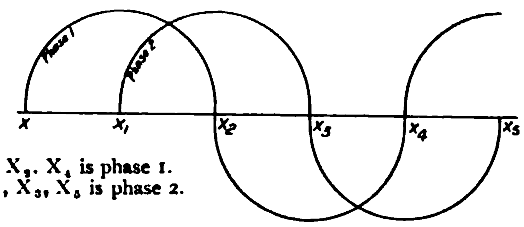
A variety of special anti-rust paints have of late appeared upon the market, their office being to give a stronger, more elastic covering than ordinary paint affords.

To light engineering work, however, these are not especially applicable, and for this purpose a process (patent No. 8667/06) invented by Mr. T. W. Coslett, of Birmingham, is likely to be widely adopted. This consists in immersing the article in a hot phosphorized solution together with an iron compound. The surface of the iron is converted into a mixture of ferrous and ferric phosphates, and presents a pleasing dull-black appearance. The process makes the iron highly resistant to corrosion, and is being applied to all kinds of light engineering work, such as cycle frames, gun-barrels, stampings and press work.

Distribution of Current to Trains on Electric Railways.—VI.

Distribution by Two and Three Phase Alternating Currents.

At the present time one of those interesting struggles that are so common in the engineering world is taking place between distribution by single phase and by three phase alternating currents. Two phase currents are also employed to a limited extent, but the main struggle is between single phase and three phase. Two phase and three phase alternating currents were introduced when the large development in the use of electricity for lighting and power took place, some ten or fifteen years ago, because, as already explained, the single phase motor would not do what the continuous current motor will. It was practically out of the running for the great majority of power work, and particularly for railway locomotive work. Two phase and three phase motors will do practically all that continuous current motors will do, and they have certain features of their own that are advantageous in certain cases, but are disadvantageous in others. They run at practically uniform speeds, for instance, under all loads, until a large overload is reached, the amount of overload depending upon the construction of the motor. There is not space in these articles to deal with the construction and working of two and three phase motors, but it will be wise to understand what two and three phase currents are. Single phase alternating currents were described in a previous article. Two phase currents are merely two single phase currents, generated in one machine, and used in one motor. The two currents are generated perfectly independently in the generator, and are used perfectly independently of each other in the motor, and have to be conveyed from generator to motor also perfectly independently of each other. The two currents rise, and fall, and reverse exactly in the same way as the single phase currents do, but an interval occurs between the two currents, equal to a quarter of the period covered by the cycle on



X, X_2, X_4 is phase 1.
X_1, X_3, X_5 is phase 2.

Fig. 27.—Diagram of two phase currents.

which the alternating current is working. Fig. 27 shows diagramatically the arrangement of two phase currents. One current commences from O, rises to its maximum, falls to O, reverses, rises to a maximum in the opposite direction, falls to O, and recommences again. The second current does not commence until the first current has reached its first maximum, and is always a quarter of the full period behind it. It rises and falls and reverses, just as the first current does, but it reaches its maximum when the first current has reached its second zero. The second current reaches its second zero when the first current has reached its second maximum, and so on. With three phase apparatus there are three distinct currents, each rising and falling and reversing, just as the ordinary single phase current does, the three currents following each other at intervals of one-third of the total period. Thus, the first current has passed its

*No. I. of this series appeared in the *Railway Engineer*, August, 1907; No. II. in October, 1907; No. III. in December, 1907; No. IV. in February, 1908; No. V. in April, 1908.

first maximum, and has reached a position one-third towards its second zero, before the second current commences, and when the second current reaches its first maximum the first current is one-third of its way towards its second maximum. The third current does not start until the second current has passed its first maximum and reached a position one-third of the way towards its second zero, the first current having then reached a position two-thirds of its way towards the second maximum. The three currents follow each other in this way just as the two currents do. Fig. 28 shows three phase currents diagramatically. There is one peculiar feature about the three phase currents; the algebraical sum of the three currents or the three pressures at any moment is O. Fig. 29, which is the clock diagram reproduced, will show this for one case. As before, the radius moving round

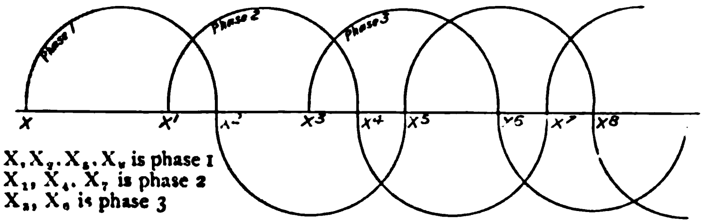


Fig. 28.—Diagram of three phase currents.

the centre O sweeps out the angle, the sine of which represents either pressure or current, as may be arranged. Taking, as before, X Y X Y as the circle, swept out by the radius, and assuming the third phase to be at O^0, the second phase will then be represented by O P^2 and the first phase by O P^1. The perpendiculars P_2 N and P_1 N dropped from P_2 and P_1

Clock diagram showing that the algebraical sum of the pressures or currents with three phase at any instant = O, P_3 = O, $P_2 = P_1 = O$.

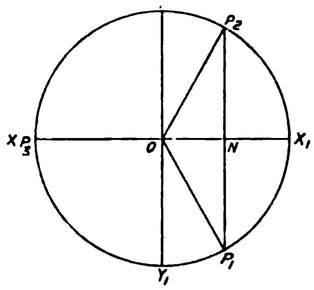


Fig. 29.

upon the X O X_1 which represent the values of the sines of the second and first phase respectively, it will be seen coincide, and are equal and opposite. As the sine of the third phase is also O, the algebraical sum of the three is O. And this applies to any position in which the three phases may be. Clock diagrams made with the different phases, in different positions, but always 120° apart, will show that the algebraical sums of the values of the sines are always equal to O. Two phase currents are carried by two independent circuits, and in the ordinary course of working require four wires. It is as though two single phase machines were connected together by their axles, each delivering its current to its own wires. But there is a method of working two phase apparatus with three wires, the third wire forming the common return. This arrangement is perfectly practical, because the two currents being spaced in time, a quarter of a period apart, do not interfere with each other in the third wire. In ordinary power work it is usually not wise to employ this arrangement, because there is always the danger of making connection between the two wires of the two phases, for supplying current to lamps, where the connection should be made between one of the wires of the two phases and the common third wire. With railway work this objection does not hold, and therefore two phase currents are sometimes employed, with two overhead conductors, the rails forming the common return. It will be seen that the arrangement is practically a duplication of single phase distribution. Further, in a few cases the duplication has been carried so far as to divide the two phases, using one phase say for up line trains, and the other phase for down line trains, in very much the same manner as explained in connection with the three wire system employed on the City and Waterloo R.

There is the same objection to the use of the rails for a return with two phase currents as with single phase. The objections are in fact accentuated by the fact of the rails having to carry the two sets of currents, but the convenience of the employment of the rails as a third conductor is so great that the other objections have been overruled. In addition, the writer understands that return conductors have not always been employed where the rails are used for a return either with two or three phase currents, the skin effects mentioned in a previous article being lessened by reducing the periodicity of the service.

By periodicity is meant the number of complete cycles, the number of complete alternations, positive and negative, from the first zero, through the first maximum, through the second zero and the second maximum to the third zero, that occur in one second. In the early days of alternating currents, when they were only employed for lighting, periodicities as high as 166 per second were employed, but such figures would be absolutely unworkable for railway purposes. The number of periods or cycles has been steadily decreasing. For ordinary lighting work it now stands usually at about 50 per second, 3,000 per minute, and for power work it has fallen as low as 15 per second. Where lighting is taken from the same service as power the sensitiveness of the electric incandescent lamp to small changes of pressure has ruled the minimum number of periods that could be employed. When the alternating currents succeed each other very rapidly, as with 100 periods per second, and even with 50 periods per second, there is no appreciable change in the heating effect produced in the carbon filaments of the lamps; but when the periodicity is 25 a very keen observer may sometimes see slight changes, and at 15 periods it is distinctly visible. Again, however, the great convenience attending the use of the rails, and the effect that a wink in the lamps of a railway train, does not seriously matter, considering the fact that passengers' eyes are in a constant state of vibration, owing to the motion of the train, and therefore a periodicity of 15 is being established in connection with railway work. The low periodicity has a very important effect upon the increase of resistance mentioned, due to the inductive effect between the particles of the conductors themselves, owing to the rapid changes in current. The less rapid the changes the less is the inductive effect, and the less is the screening effect upon the conductors.

Distribution with Three Phase Currents.

As indicated above, two phase currents have not come much into use for railway work. Either single phase or three phase currents are employed in all cases where alternating currents can be used; and further, the distribution service, even where single phase currents are employed, is carried out by means of three phase currents.

The arrangement of three phase currents was described

above. For their distribution only three conductors are required, as against four for the usual two phase distribution; but on the other hand, where it is convenient, four wires can be employed with three phase working. As explained, three phase currents may be considered as being generated by three independent single phase machines, arranged for convenience in one, but there is the peculiar feature mentioned above, that only three wires are required for distribution. On the generator, and on the motor, there are three distinct sets of coils, each set of coils generating current independently in the generator, and receiving current independently in the motor. But the feature mentioned above, that the algebraical sum at any instant of the three currents, or the three pressures, enables only three conductors to be employed for distribution. The three conductors may be looked upon as forming three independent circuits. Calling the three conductors 1, 2 and 3, conductors 1 and 2 with the coils of the generator and the coils of the motor between them, form one complete circuit, independent of the others, except for what is called mutual induction. Conductors 2 and 3, with the coils of the generator and motor connected to them, constitute a second complete circuit quite independent of the others, except again for the mutual induction mentioned. Conductors 1 and 3, with the coils of the generator and motor connected to them, form a third complete circuit, independent of all the others, except for mutual induction. It should be mentioned that induction takes place between the coils of the different phases, on both the generator and the motor, and also between the conductors carrying the currents of the different phases, this being known as mutual induction. There is not space in these articles to deal with this matter, and therefore it will be merely noted, with the remark that every effort is made to reduce the mutual induction between the currents as much as possible, and for that purpose the conductors are kept as close together as they possibly can be.

It will be seen that, just as with the two phase system, the three phase system may be looked upon as three single phase currents, and the three currents may be used independently, providing that a balance is always maintained between the three. The mutual induction mentioned above increases very rapidly if one of the phases, either in a two or three phase system, is more heavily loaded than the others. This, it will be understood, constitutes one of the problems involved in the adaptation of three phase currents for railway work.

There are three methods therefore by which three phase currents may be employed to deliver currents to railway trains.

(1) The three currents may be delivered to the train by three overhead trolley wires.

(2) The three currents may be delivered to the train by two overhead conductors, and one conductor occupying the same position as the return with a single phase service.

(3) Two phases may be taken from two overhead conductors, arranged to supply two different lines of railway, say the up and down line, or two different sections of railway, both up and down line, the third conductor occupying the position of the return, as in the single phase system.

(4) The three phases may be taken from three overhead conductors, each independent of the other, and each having a conductor fixed in the track, either the rails or a return conductor, as with single phase currents, the one return being common to all the phases.

The first method was that employed in the special experiments on high speed working that were made in Germany. It was thought that at the very high speeds that were contemplated it would not be wise to employ the track, nor even a conductor bonded to the track, for a return, and therefore the three overhead conductors were fixed by the side of the line, vertically one above the other, and three special trolleys of the bow type were arranged to make contact with them. So far as the writer is aware, this is the only case in which three overhead conductors have been employed for three phase railway working.

The second method is that which has been employed with such success in the Swiss Burgdorp-Thun R. that was electrified by Messrs. Brown, Boverie and Co. some 9 or 10 years back. It was also employed on the Valtellina R., and other railways have adopted it since.

The third and fourth systems are gradually coming into use, in different parts of the world, as the single phase motor is developed. The single phase motor pure and simple, it will be remembered, is not a practical one for railway work, but the continuous current motor, with tappings for single phase currents, in addition to the usual commutator for continuous currents, and with special arrangements for meeting the different requirements of working, has proved a very successful apparatus, and it is leading to the use of single phase currents for railway work generally.

With the use of three phase currents and single phase currents the pressure employed at the trolley wire and between the trolley wire and earth has steadily increased. It will be understood, from what has gone before, that the more the pressure can be increased the smaller the current that has to be delivered to the moving train, and therefore the greater the ease with which it is collected, and the easier the working of the system generally. In the Burgdorp-Thun R., referred to above, the pressure between the three phases, and therefore between each of the overhead trolley wires and the track, was 750 volts. At the time when this plant was installed a considerable uncertainty existed as to the safe limit that might be adopted for overhead trolley wires in railway working. Up to that time 500 volts. had been the pressure employed for town tramway services and for the short railways that had been electrified, this pressure having been taken by the American electrical engineers for their early installations as the limit that was considered safe in those days. The authorities who were responsible for the working of the Burgdorp-Thun R. were anxious to have the railway run at this pressure. The engineers, on the other hand, wished to raise the pressure to 1,000 volts, and accordingly a compromise was effected, and the system was worked at 750 volts. The Valtellina R. is worked at 3,000 volts, and the great majority of the railways, single phase, two phase and three phase, that have been established since have adopted that pressure. Recently, however, the tendency is to increase the pressure to 6,000 or 6,600 volts, and for the following reasons. As explained in previous articles in *The Railway Engineer*, in any electrical distribution system, doubling the pressure allows a conductor of a quarter the size to be employed to distribute any given amount of power, whether for lighting or traction, to any

distance; or *per contra*, doubling the pressure and keeping the trolley wires the same size quadruples the economical distance over which the current can be distributed. On the other hand, there appears, so far as experience up to the present goes, to be no difference between the danger to life from 3,000 volts and 6,000 volts. In fact, after a pressure of something like 100 volts alternating is passed the danger to life appears to be practically the same until very high pressures indeed are reached; and further, it has been found in practice, paradoxical as it may seem, that very high pressures are even less dangerous to life than comparatively low pressures. Many men have received very severe shocks from very high pressures, and have escaped with merely a severe burning, while others who have been subject only to very low pressures, 200 volts and less, have been killed. And the reason is, it very frequently happens that when a man touches a conductor in which a very high pressure exists he does not grasp it, as he frequently does with a comparatively low pressure conductor, and consequently an arc is formed between the conductor and his hand, or whatever part of his body has accidentally touched the conductor, the arc searing the flesh very painfully for the time, but effectually barring the passage of a killing current owing to the very high resistance set up by the charred skin, etc. The use of high pressures also is incidentally of advantage in another way. It enables the number of sub-stations to be considerably decreased, and sub-stations, it will be understood, mean expense, even when they only consist of stationary transformers fixed on poles by the side of the line.

(To be continued.)

Official Reports on Recent Accidents.

At **West Hampstead Station, Met. R.** *On 26th October. Major J. W. Pringle reports that*:—

The 7.37 a.m. down train, Baker Street to Willesden Green, standing at the platform, was run into by the 7.41 a.m. *ex* Baker Street to Neasden.

Each train was composed of six 8-wheeled coaches, the first and last being motors. The colliding cars were telescoped. The under frame of the moving car passed underneath the platform of the standing car, whilst its body forced its way for a distance of 36ft. inside the other body.

The motorman of the colliding train was seriously injured, 25 passengers were injured and 3 were killed.

Both trains were fitted with the Westinghouse quick-acting automatic brake.

The collision occurred about 7.52 a.m., during a thick fog.

West Hampstead Station is between Finchley Road and Kilburn-Brondesbury Stations. The arrangement of lines, etc., at West Hampstead is shown on the plan. The line rises from Finchley Road through West Hampstead at 1 in 263.

The railway is equipped with the block system of electric lock and block signalling devised by Mr. Spagnoletti. By this invention the movement of a train over treadles releases the block instruments. These in turn, when operated by the signalman, release the levers by which the outdoor signals are worked.

Dealing with the down line only, between Finchley Road and Kilburn Stations, there are in the signal-box at West Hampstead three movable dial or disc instruments in use for working the traffic, in addition to the bell instruments. One of these (referred to hereafter as A) is known as the down disc instrument to Finchley Road, and deals with the section of the line between the starting signal at Finchley Road and the home signal at West Hampstead. This section of road is controlled by the mutual co-operation of the two signalmen at Finchley Road and West Hampstead. The disc readings in this instrument (A) are three in number:—1. Train on line—on a red disc. 2. Line clear—on a white disc. 3. Neutral—half red, half white disc. The readings are duplicated in a similar instrument (A^1) in Finchley Road signal-box. The second, referred to hereafter as (B), is known as the down "additional" disc instrument, and deals with that section of the line between the down home and down starting signals at West Hampstead. The signalman at West Hampstead has sole control over this section of road. There are only two positions of the disc in this instrument, viz.: "Train on line" and "Line clear." The third (C), known as the down disc instrument to Kilburn, refers to the line between the down starting signal at West Hampstead and Kilburn. Again, two signalmen, *i.e.*, at West Hampstead and Kilburn, are mutually responsible for the working for this section, and an instrument (C^1) at Kilburn duplicates the instrument (C) at West Hampstead. The normal position of all these instruments is with the disc showing "Line clear."

The method of signalling is as follows: F. H, and K, representing the signalmen at the three stations. F signals a train on the bell instrument to H, in accordance with the Bell Code, and unpegs the white key of his instrument A^1. If the line be clear, H acknowledges the bell signal by repetition, presses down the red key of his instrument A, and lowers his down home signal. He releases the lock of this signal lever by pressing down the key of his instrument (B). The action of pressing down the red key of instrument A electrically releases the lock on the starting signal at F, and causes the "Train on line" red disc to appear on both the instruments A and A^1. F then lowers his starting signal and replaces it to danger when the train has operated a treadle in advance of it. F's starting signal now remains locked until it is again released by H. When the train has passed over the treadle 167 yards in front of the down home signal at H, the disc of the instrument (A) will be released, and, simultaneously with that of (A^1), will swing into the neutral position. H then rings "Line clear" on his bell instrument to F. F acknowledges this bell signal by repetition, and pegs the white key on his instrument (A^1) to "Line clear." This causes "Line clear" to show on the disc of instrument (A) also. H replaces his down home signal to danger, and signals the train to K, who releases the starting signal at H in the same manner as was done by H for F.

At this moment the disc of instrument (B) will be showing "Train on line," and, so long as it remains in this position, H cannot, in normal working, again lower his down home signal to allow a train from F to enter the station. When the train has left H, and passes over a treadle 103 yards in advance of the down starting signal, the "Train on line" disc in (B) is electrically released and the disc "Line clear" is automatically displayed. Signalman H can then, by pressing down the key of his instrument (B), release the lock on his down home signal.

Shortly, the electrical interlocking ensures that the passage of a train over a treadle in front of the home signal at West Hampstead releases the instrument (A). This release allows the signalman at West Hampstead to free the lever working the down starting signal at Finchley Road. Again, the passage of a train over a treadle in front of the down starting signal at West Hampstead releases the disc instrument (B) which permits the signalman at West Hampstead to free the lever working his own down home signal. It must be noted that the disc instrument (B) is only released if the treadle in front of the down starting signal is operated whilst the starting signal lever is in the safety position. If the signal lever is at danger when the treadle contact is made the instrument (B) will not be released.

Lock indicators are provided in the signal-box behind each signal lever which is electrically controlled. These visually indicate whether the lock is "on" or "off."

In case of a failure of the electrical releasing arrangements, or when a train arrives at the station, but does not proceed further, it is necessary to provide means whereby the signalman can release his disc instruments, and his lever locks. For this purpose there are fixed in the signal-box a number of small release boxes with glass fronts. These contain release springs, which when operated by hand release the disc instruments.

Extracts, from the General Rules and Regulations, from the Instructions for Working the Lock and Block System, and from the Instructions respecting the use of the release or key-boxes, which have a bearing upon the conduct of the men concerned in this case, are as follows:—

(1) Extracts from General Rules and Regulations applicable on the Metropolitan Railway.

6. The safety of the public must, under all circumstances, be the chief care of the servants of the Company.

Detention at home or starting signals.

55. On any occasion when the presence of a train . . . . may be unknown to, or may have been overlooked by, the signalman, the engine driver must immediately sound his whistle, as a reminder to the signalman of the position of the train, and continue doing so at frequent intervals.

(*a*) In case of detention at a home, starting . . . . signal, the engine driver must immediately sound his whistle, and, if still detained, the guard . . . . must . . . . notwithstanding the lock and block system of train signalling being in operation, go into the signal box and remind the signalman of the position of the train, and remain there until the signalman can give permission for it to go forward.

In foggy weather . . . . the guard . . . . must immediately upon the train coming to a stand, proceed to the signal box.

Working of points and signals.

56 (*a*). In case of failure of any of the electrical or mechanical apparatus, immediate notice must be sent to the linesman or signal fitter, as the case may be, whether the defect continues or not.

61. When a signal other than a distant signal has been lowered for the passing of a train, it must not . . . . be again placed at danger, until the last vehicle of the train has passed it . . .

61A. If the full view of the train from the signal box is obstructed by fog or any other cause, the stationmaster or other person in charge must arrange for a competent man to advise the signalman when each train has passed clear of the station.

Signalling in foggy weather, &c.

78 (*a*). In foggy weather . . . . it is the duty of a stationmaster or other appointed person to take care that fog-signalmen are employed at all places where their services are required . . . .

(*aa*) During foggy weather . . . . it is the duty of the foreman of the permanent way to take care that fog-signalmen are provided when necessary at all places where their services are required.

Control and Working of Stations.

90 (*a*). Every stationmaster or person in charge of a station . . . is responsible for the faithful and efficient discharge of the duties devolving upon all the Company's servants . . . . employed at the station, and such servants are subject to his authority and directions in the working of the line. He is also responsible for the general working of the station being carried out in strict accordance with the Company's regulations . . . .

96. The stationmaster must make himself thoroughly acquainted with the duties of the signalmen at his station . . . . and satisfy himself that they perform them in a proper manner . . . . and in order to maintain a proper supervision over the men in this respect, he must frequently visit the signal-boxes.

(2) EXTRACTS FROM INSTRUCTIONS FOR WORKING THE BLOCK SYSTEM, COMBINED WITH SPAGNOLETTI'S ELECTRIC INTERLOCKING APPARATUS.

Revised Code of Bell Signals in operation on and after 30th June, 1904.

	Beats on Bell.	How given.	How acknowledged.
For ordinary passenger train ...	1	—	Repeat and peg 'Train on Line' on Disc Instrument.
For passenger train to or from Baker Street and Willesden Green	4	1, pause, 2, pause, 1.	Ditto.
For Line Clear	3	Consecutively.	Repeat and peg 'Line clear.'

NOTE.—No signal must be considered complete until acknowledged by exact repetition.

In all cases of failure of the electric locking, however caused, and whether intermittent or continuous, the lineman and person in charge of the station must be immediately advised, the circumstances must be recorded in the train report book, and full particulars reported.

Whenever it is necessary to break the glass of a key box, it must at once be replaced by the person in charge of the station, who is provided with a supply of glasses for that purpose, and he must keep a record of the number of glasses received and how disposed of.

The signalman must also record each case of breaking a glass, and the time, in his train report book.

The keys for unlocking the boxes in the station must be kept in the station inspector's room, and in readiness for use whenever required.

The delaying of trains is of secondary importance to incurring risk.

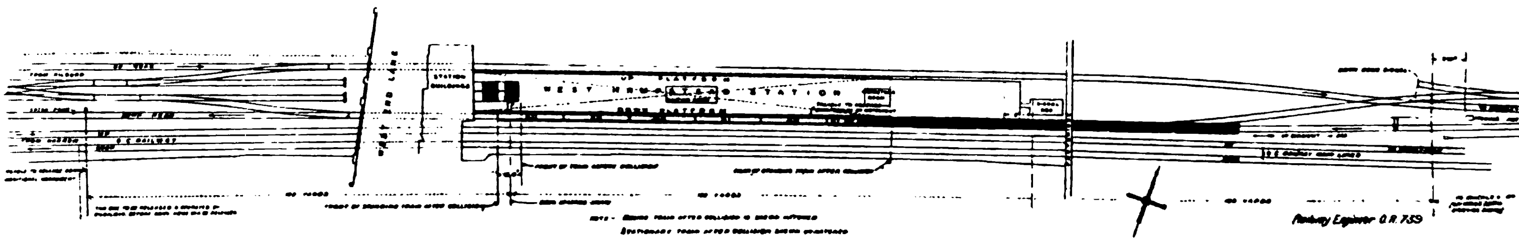
26th September, 1907.

This is a complicated case, and it is made more difficult by much confliction of evidence on material points.

Both the trains concerned in this collision were duly signalled from Finchley Road, and accepted by signalman Hollis at West Hampstead. The first (Willesden Green) train was standing at the down platform at West Hampstead, when the second (Neasden) train was admitted to the station with all proper signals lowered, and the collision resulted. A thick fog prevailed, so that although the tail end of the Willesden Green train was only about 30 yards distant from the signal-box, it was in all probability invisible to signalman Hollis. A fogman (Tomes) was in position—about 160 yards in rear of the standing train—protecting the down home signal. But, as all are agreed, both the down distant and down home signals had been lowered for the Neasden train, and Tomes had quite properly therefore removed his detonators, and was displaying his green flag, when the train passed. Motorman Smith, the driver of the Neasden train, was prepared to stop if the West Hampstead home signal was at "danger." Both the semaphore arm and the fogman's green flag authorised him to proceed. He therefore allowed the train to run free by releasing the continuous brake. Not until within about 20 yards of the standing train was Smith able to see it, and a collision was then inevitable.

Hollis gives the following account of his dealings with these two trains:—

1. His usual practice was to offer a down train to Kilburn, when it had arrived at West Hampstead. Contrary to this usual custom, he offered the Willesden Green train, had it accepted, and lowered his down starting signal very soon after he had accepted the train from Finchley Road, and some time therefore before the train arrived at West Hampstead. He estimates that the approximate time for this action was 7.45½ a.m.



1. . . . . ,

The keys of the bells and discs must be pressed down slowly and firmly to ensure proper contact.

3. All signals must be kept at danger. They must only be pulled off when the lines are clear for a train to proceed, and on the passing of a train must be replaced at danger immediately, but . . . . not before the train has operated the treadle, as indicated by the disc being released and swinging to the neutral position.

9 (*a*). Giving Line Clear . . . . If the full view of the train is obstructed by fog, or any other cause, the signalman must at once inform the stationmaster, or inspector, who must appoint a man to inform the signalman when each train has passed clear of the station.

(*d*) *Note.*—Signalmen are warned that the provision of the electric locking in no way relieves them of the duty of strictly observing every precaution . . . . and especially of personally satisfying themselves that the line is clear, before allowing another train to approach, or leave.

(3) EXTRACTS FROM INSTRUCTIONS TO STATIONMASTERS, INSPECTORS AND ALL CONCERNED RESPECTING THE USE OF KEY BOX FOR THE PURPOSE OF RELEASING ELECTRIC LOCKING.

The stationmaster or station inspector is personally responsible for the due carrying out of the following instructions . . . . and for making such arrangements as will ensure these instructions being rigidly acted upon by the person in charge in his absence.

Failure of Electric Locking.—Each signal-box is provided with keys for releasing the locking in case of failure; the keys are locked up in a box, and the stationmaster or inspector on duty is the only person authorised to unlock the key box for the purpose of releasing the locking. If a failure occurs at any station signal-box it must be immediately reported to the person in charge of the station, and the train must be stopped at the signal for his authority to the driver to proceed.

. . . .

2. He then proceeded to enter in his train register book the timings of several up and down trains. Whilst so engaged he heard the noise of a train approaching, and judged it was the Willesden Green train. He therefore entered in the train book the arrival and departure of this train as 7.46 and 7.46½, and at the same time, in accordance with his general practice, he booked the time of the receipt from Kilburn of the clearance signal for the train as 7.48.

3. Shortly afterwards, turning towards the lever frame, he saw that the discs of his down "Kilburn" and down "additional" instruments were both showing "Line clear." This would indicate that the Willesden train had arrived at Kilburn, if all was correct. He had not then cleared back to Finchley Road for this Willesden train, and all his down line signals were standing at "Clear." He therefore replaced all his down line signals at danger, and cleared back to Finchley Road on the bell instrument.

4. Therefore when the Neasden train was offered him, he accepted it, released his down home signal lock in the usual manner, by working the tapper of his down additional disc instrument, and lowered the down home and distant signals, so that the train shortly afterwards entered the station, and the collision took place.

Since clearly the lock on the down home signal lever was released, as the signal was lowered, the question remains—how was the additional instrument unlocked? It will be seen in the descriptive part of the report that, with any system of "Lock and block" signalling, it is necessary to provide a means whereby a release of an instrument, or of a lock on a signal lever, may be obtained in cases of failure, mechanical breakage, or for cancelling trains. On this system, spring contacts which can be worked by hand are provided for the release of the instruments, and keys for locking the levers. The spring contacts and keys are enclosed in small glass-faced boxes. These boxes are kept locked, and the key for opening them is in the charge of the stationmaster or station foreman. The instructions relating to the use of these release

boxes are given in Appendix II. (3). Only a stationmaster, or station foreman, is authorised to open any of these boxes with the key. Where a release is required for the purposes of ordinary working, *e.g.*, for cancelling a train, signalmen are authorised to break the glass face of the release box. They are ordered to report all such breakages, and the station foreman or stationmaster is alone authorised to replace the glass from a store in his possession. It is necessary to open the case of the release box by means of the key in order to replace the glass. It is not an uncommon occurrence for a glass to be broken in accordance with the instructions to meet ordinary traffic requirements. From a list furnished by the Company, there have been 20 cases reported at West Hampstead since the commencement of 1907. Of these 20 cases, 5 were reported by signalman Hollis. None of the glasses were found broken after the accident. Nor was this a case where a man would be justified by the rules in breaking a glass. It would be his duty, if any failure to release took place, to send for the stationmaster or station foreman, and state the necessity for obtaining a release. Some years ago it was possible—*vide* signalman Shepherd's evidence—to insert a thin piece of steel into a release box, and unlock an instrument by depressing the spring contact. But the construction of the glass front of the box has been altered to prevent this. It is not unknown—a case is cited by chief inspector Lyons—for a signalman to possess a key which will open these release boxes. The lock of these release boxes is of the lever pattern, and the key, which has five tumblers, is not of a complicated description. If Hollis owned a key of this pattern, he could have opened the box, pressed the spring, and thus made it possible for himself to release the lock on the down home signal. There is no evidence of any description to show that he had such a key in his possession at the time of the accident, and as no one was in the signal-box with him, it cannot be directly proved that he opened one of the release boxes on this occasion. But without breaking a glass, or opening a box with a key, it would not have been possible to obtain a release of the down home signal lever.

Regarding the neglect of certain rules, &c., which have a bearing on this accident:—

1. Rule 9 (*a*) of the Instructions for working the Block System lays down that a signalman must inform the person in charge of a station when the full view of a train is obstructed by fog, and apply for assistance. Hollis did not carry out this rule. He explains that he did on one occasion apply for assistance to a station foreman, who has since retired from the service, but that he was told that assistance was not necessary. He did not, it appears, make any further application, and signalman Matthews, also employed at the West Hampstead signal-box, admits he had never applied for assistance in accordance with this rule, as he had not thought it was necessary with the safeguards supplied by "lock and block" signalling.

There is also a special rule, No. 61 (A) (1), applicable on this railway, which requires the person in charge of a station to appoint a competent person to advise the signalman in foggy weather when each train has passed clear of the station. As worded, it is not necessary for a stationmaster to wait for an application from a signalman for assistance. He is ordered to provide a man in foggy weather. This rule never appears to have been carried out at West Hampstead. The signalmen have evidently therefore acquired the habit of relying implicitly upon the safeguards provided by the "lock and block" system, and of disregarding the Note under 9 (*d*) of the Instructions for working the block system.

2. General Rule 96.—Stationmasters are responsible that signalmen perform their duties in a proper manner. The supervision of the signalmen's work at West Hampstead has not been satisfactory.

3. General Rules 55 and 55 (*a*).—The last mentioned appears to be most relevant. It is not applicable on most railways in the United Kingdom, when trains are standing at a station platform. On the Metropolitan the rule is applicable at all places. Motorman Spittle stated that he did not know it was applicable within a station, but both motorman Smith and guard Sills were aware of its applicability, and it is not easy to understand why Spittle should have thought otherwise. Spittle also admits that he has on other occasions sounded his whisle, when delayed at a station.

The usual time occupied by a train at West Hampstead platform is about half a minute. On this occasion the men estimate that it stood for 3 or 4 minutes. But in accordance with the booked timings the Willesden Green train arrived about 7.46 and the collision occurred about 7.52. The delay therefore actually amounted to 5 or 6 minutes. It is difficult for a guard to decide, when he is momentarily expecting the signal to be lowered, what is the proper moment for carrying out this rule, as he runs a risk of delaying his train if he proceeds to the signal-box and the signal is lowered in his absence. But safety is of more importance than a minute or two of delay, and the Company's rules emphasise this. Sills in his evidence states he did start to go to the signal-box just before the collision happened. Having regard to the actual delay to the train, he should have started earlier.

4. The instructions regarding the use of the release boxes have not been properly obeyed. There is no record of glasses received and how disposed of. Signalmen have not reported in the train book all failures which have occurred. In March last Fitch was appointed station foreman at West Hampstead. He states that he knew of only two cases when he had been called upon to replace glasses in the release boxes. During this period about a dozen instances of broken glasses have been recorded. It appears therefore either that unauthorised persons must have used the key to replace the glasses, or the key must have been used in the first instance to obtain the releases, and the glasses were not broken as reported.

5. The windows in the signal-box facing the down line were covered with paint at the time of the accident. They had been painted at the request of the signalman in order to keep out the glare of the sun. It was impossible to see through these windows, and the fact that for some lengthy period this condition had prevailed shows, I think, that the signalmen had acquired the undesirable habit of not observing the trains, but were relying entirely upon their lock and block instruments. The paint has since been removed.

After carefully weighing all the evidence in this case, and taking into consideration all the possibilities of failure in the signalling arrangements, the following conclusions are arrived at:—

1. That the first (Willesden Green) train was not, on arrival at West Hampstead, put into block to Kilburn, and that the starting signal was consequently not lowered. The result was that the train was kept standing at the platform for five or six minutes before the collision happened.

2. That, in all probability, owing to the thick fog, the train, as it stood at the platform, was out of sight of the signalman, but nothing was done in accordance with the Company's rules to remind him of the position of the train.

3. That the electrical and mechanical signalling arrangements were in working order, and that it was not possible, with proper usage, and in accordance with the regulations, to lower the down home and distant signals for the second (Neasden) train to enter the station, until the first train had left the station.

Therefore the collision was caused by forgetfulness in the first instance, and subsequently by some illegal manipulation of the electrical instruments or locking on the part of signalman Hollis. He must bear the full responsibility for his conduct. On the morning in question he arrived ¾ hour late for duty, after 16 hours' rest, and had been at work for about an hour when the collision took place. He has been employed by the Company for about 18 years, first as signal-box boy, and afterwards (since 1892) as signalman, and there is no serious entry in his record sheet during the last three years.

The collision might, in all probability, have been prevented if motorman Spittle and guard Sills had carried out general rule No. 55 (*a*), which is applicable on the Company's system to trains standing within station limits. To some extent responsibility falls upon these men for not carrying out this rule.

Station foreman Fitch failed to act in accordance with Rule 61 (A) and appoint a ground fog-signalman, or detail one of the station staff to assist Hollis. It is evident he has not properly supervised the manner in which the signalmen perform their duties, or observed the Company's rules regarding the use of the release key-boxes.

Signalman Boggis was wrong in accepting a train when he thought it had been improperly signalled. But having regard to the time the signal was received, *i.e.*, after the collision, as the evidence shows, this error was not a contributory cause of the accident.

It is generally recognised that an automatic system of signalling is best adapted for a railway where block sections are very short, and traffic of high frequency. The Company's system of "lock and block" signalling has done excellent service in the past. This is proved by the fact that, from the opening of the railway in 1863 until the date of this unfortunate collision, some 3,000 millions of passengers have been carried without the loss of one life in a train accident. The maximum number of trains dealt with during the winter at West Hampstead, in one signalman's tour of duty—8 hours—is 226, an average of 28·25 per hour. During the summer months the average is sometimes as high as 36 per hour. Having regard to the number of movements involved in passing so large a traffic on the "lock and block" system, a machine-like regularity of action is necessary, which can best be supplied by an automatic method of working. The Company have for some time past been experimenting with a system of train-controlled signalling, with a view to adopting it on their lines. But every detail must be thoroughly proved by long and continuous tests under working conditions before the method can be accepted. Some time, therefore, must elapse before any complete change in the signalling arrangements can be carried out.

*

***At* Farringdon Street Station, Met. R.** *On the 26th November. Major J. W. Pringle reports that*:—

The 7.40 a.m. up train *ex* Hammersmith was run into by the 7.48 a.m. Circle train from South Kensington. The collision was not violent; no wheels were derailed; 15 passengers and 5 train men were injured.

The Hammersmith train consisted of six 8-wheeled cars and the Circle train of four similar cars (motor car at each end) fitted with the quick-acting Westinghouse brake to all wheels.

Between King's Cross and Farringdon St. stations there is a tunnel ⅓m. long. The remainder of the length is in cutting, but over bridges obscure the light. An intermediate block post, Granville signal-box, in the tunnel, divides the length into two sections. The signal-boxes on either side of this block post are known as King's Cross "B" and Farringdon St. "B." The latter is at the west end of the down platform.

The up home signal post for Farringdon St. is placed on the south (or right hand) side of both the Circle lines, and is not visible to an approaching train, even in clear weather, until it emerges from the tunnel about 100 yards distant. A repeating (ground) signal, showing orange and green lights for "danger" and "safety" respectively, has therefore been provided. This signal is fixed inside the tunnel on the proper left hand side, and is worked by the same signal lever (No. 4) in Farringdon St. "B" signal-box which operates the up home signal. Owing to curvature a good view is not obtainable from an approaching up train of the lines in the station until about 100 yards from the platforms.

The signal levers are controlled by Spagnoletti's electric "lock and block."

The mechanical details for manually working the signals are those generally in use. The wires cross the main lines under the rails twice before they reach the up home signal post, so that there are many changes of direction, both lateral and vertical, requiring side or pedestal wheels, before the wires can be attached to the rods which actuate the balance levers of the semaphore arms. There is a single wire leading from the up home signal post to the ground signal in the tunnel which acts as a repeater for the two up home signals. This signal wire is attached by splices to the two wires which work the home signals. These splices, and the side wheel round which the chain attached to the wire for the repeating signal runs, are situated in the four-foot way of the down Circle road on the level of the ballast. Owing to the number of changes of direction in these wires, to the length of lead, and to the balance weights of the signals themselves, the pull on the levers is heavy. Therefore, in addition to a gain-stroke wheel and lever, three weights of 40 lbs. each have been fixed on the back tail of the lever to reduce the manual labour required to work the signals.

This accident calls for particular attention on account of the difficulty that exists in satisfactorily explaining the cause of the collision.

The first train arrived at Farringdon St. Station at 8.12 a.m.—7 minutes late. It stood at the up platform about 1½ minutes before the starting signal was lowered. The train started immediately, but had only moved about 17 yards when the collision took place. The second train was 2 minutes late at Edgware Rd., and, notwithstanding delays at Portland Rd. and Granville signal-box, had made up some time.

As to the position of the signals for Farringdon St., Motorman Heard, who drove the second train, is positive that both the repeater and the up home signal were "off." The fog was thicker after the home signal was passed, and he was prevented from seeing anything of the Hammersmith train in front of him until within 7 or 8 yards of it.

Signalman Stokes of Farringdon St. "B" signal-box is equally positive that the lever (No. 4), by which the repeater and the up home signal are worked, was in the normal "Danger" position when the first train passed. Neither of these signals is visible from the signal-box, and at the time there was no indicator in the signal-box to show Stokes whether the up home signal was obeying the movements of his lever. But signalman Curtis (Granville signal-box), on receipt of the clearance signal for the Hammersmith train, offered the Circle train and had it accepted by Stokes, who released the lock on his up stop signal. The electrical interlocking requires the replacement of the up home signal lever to danger before the signalman at Farringdon St. can release the lock on the up stop signal at Granville signal-box. It follows that Stokes must have put his No. 4 lever back into the normal danger position behind the Hammersmith train. Further, the locking does not permit of No. 4 lever being pulled over a second time, until the first train has passed out of the station, and operated a treadle in advance of the up starting signal. The locking therefore should have rendered it impossible for Stokes to have pulled over his up home signal for the Circle train. There is one eye-witness who corroborates Stokes' statement regarding the position of No. 4 signal lever at the time of the collision. Inspector Dodd was in Farringdon St. "B" signal-box at the moment. He declares that the starting signal lever was in the "Off," and all the other up line signal levers in the "On" position. If, therefore, the up home and repeating signals were obeying the movement of lever No. 4 it is evident that they ought not to have been at "Safety" when the Circle train passed them. The electrical locking arrangements were found to be in proper working order after the collision.

As the collision occurred within a few seconds, possibly half a minute, after the up starting signal was lowered for the Hammersmith train, it appears to be certain that, when the Circle train passed the repeater and up home signal, the up starting signal lever was in the danger position. As no breakage was found in the instruments or locks after the collision, the only apparent possible way of obtaining a release of the lock on the up home signal was by using the key box. Inspector Dodd states that he is satisfied this was not done.

In support of Heard's contention that the signals were at "Safety," it must be remembered that there is a train stop arm, or brake trip, fixed at the up home signal. The actual measurements after the collision showed that the trigger should have struck the head of the train stop, with the signal at danger, at a point about 1 inch from its edge nearest to the rail. There is also an isolating cock on the brake valve. Unless this cock is open a movement of the trigger does not apply the brake. Hodge, who examined the trigger from the ballast in the six-foot way about three minutes after the collision, and apparently before anyone else could have tampered with it, states that the trigger was hanging in its vertical position, and the isolating cock was open. It is also proved that the Circle train was "tripped" at the starting signal at St. James' Park Station, where tests are made by the Metropolitan District Railway of the efficacy of the "train stop" arrangements. The trigger was then replaced in its proper position by the man appointed for the purpose. If it had not been so replaced the continuous brake could not have been released.

Experiments made by the Co. to discover if there was a liability at this signal of the trigger failing to make contact with this particular train stop in the danger position, but on each occasion contact was made, and the train was brought to a standstill in from four to five coach lengths.

The evidence points to two conclusions, first, that the lever working the up home signal was in its proper "danger" position, and, second, that the "train stop" was not in the "danger" position when the Circle train passed. It is only possible to account for this by the supposition that the signals hung off instead of going to danger when the lever was put back behind the Hammersmith train. This would happen if the wire working the signals became entangled in the side or pedestal wheels, or elsewhere, and thus prevented the balance weights of the signal arm from acting.

*

At **Crewe Station, L. & N.W.R.** *On the 14th January. Lt.-Col. H. A. Yorke reports that:—*

The passenger train due to leave Crewe for Chester at 8.0 p.m. was run into in rear by the 4.10 p.m. passenger train from Bristol; 9 passengers slightly injured.

The Bristol train consisted of the tender engine "Precursor," eight 8-wheeled vehicles, and one 6-wheeled van (equal to 13), fitted throughout with the vacuum brake. The brake was in good order and was last tested at Shrewsbury Station.

Both the engines, all the vehicles of the Chester train, and 6 of the vehicles of the Bristol train, were damaged.

The place where the collision occurred was 59½ yards from the south end of No. 1 platform at Crewe Station.

This collision was due to want of care on the part of driver Womersley. Stations such as Crewe are worked on the "permissive system," and in order to enable it to be carried out a special code of bell signals has been instituted at Crewe between South Junction box and A box, and between A box and North Junction box, and "Calling-on arms" have been provided where necessary. The entrance into Crewe Station from Shrewsbury is controlled by South Junction box. The signals applicable to the Shrewsbury line, which are worked from this box, are inner home, outer home, and distant, and underneath the outer and inner home signals there are "calling-on arms." When a platform line is clear through the station from the South Junction to the North Junction, the home signals referring to that platform are lowered, but when there is a train or engine on any of the lines between South and North Junction the home signals are not lowered, and the "calling-on arms" are brought into use. In this way a driver approaching Crewe receives an intimation as to whether the line or platform to which he is signalled is clear, or whether he is to expect to find another train in front of him. According to the Rules, a "calling-on arm" should not be lowered until the train has come to a stop at the home signal to which the "calling-on arm" pertains.

In this instance driver Womersley admits that on approaching Crewe he found the outer home signal at danger, and that he stopped at it, waiting for permission to enter the station. After standing there for two minutes the "calling-on arm" for No. 1 platform line was lowered, and he drew down towards the station. On passing the signal-box, in front of which the inner home signals are erected, he found the "calling-on arm" there also lowered, and he received a green hand signal from the signalman, which was an additional reminder that he was to proceed cautiously, as there was a train in front. Womersley did not see the green light himself, but his fireman saw it and told him about it, and he admits that he knew quite well what he had to do, and where he had to go. The train is said by the signalman to have been moving very slowly at the time, and Womersley says he had some difficulty in keeping it on the move owing to the rails being slippery. But shortly after this, inspector Charles Cook, who was in the sidings on the west side of the station, saw the train approaching No. 1 platform and thought it was going too fast, the speed then being about 10 miles an hour. Cook was not certain whether the Chester train had left the station or not, but for safety's sake he shouted to driver Womersley to warn him that he was travelling too fast. Womersley heard the shout, and at the same time he saw the end of the Chester train about 50 yards in front of him. He immediately applied the vacuum brake and reversed his engine, but the distance was too short and he struck the rear of the Chester train, according to his own story, at a speed of six miles an hour, but the guard of the Chester train puts the speed at a much higher figure.

Womersley excuses himself by saying (1) that he did not see the tail light of the Chester train because it was obscured by steam; (2) that there were no side lights on the Chester train. There is no doubt whatever that the train was equipped with tail and side lights, and that they were burning properly; but, as frequently happens, the latter were not attached to the last vehicle of the train, but were on the third coach from the rear of it, and were hidden from Womersley's view by the rear coaches. But it was not necessary for Womersley to look for side lights; the tail light should have been his guide. Moreover, as the platform alongside which the Chester train was standing was brightly lighted, there could have been no difficulty whatever in seeing the train, had Womersley been keeping a proper look-out. He had been on duty rather less than 8 hours.

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Contents.

Mr. T. R. Wynne, C.I.E., has been appointed Chairman of the Indian Railway Board in succession to **Sir F R. Upcott**, who has retired, and **Mr. S. Finney**, formerly manager of the North Western State Railway system, has been appointed to succeed Mr. Wynne as a member of the Board.

The Duke of Devonshire has been elected chairman of the Furness R. in succession to the late Duke, and **Mr. Richard Frederick Cavendish**, of Holker Hall, Cark-in-Cartmel, his brother, has been elected a director of the company.

The Earl of Kerry has been elected a director of the Great Central R.

Lord Armstrong has retired from the Board of the North Eastern R.

Mr. J. G. Griffiths, Hyde Park Gardens, W., a member of the Shareholders' Audit Committee, has been elected a director of the Great Western R. in succession to the late Mr. Alfred Baldwin. Mr. Griffiths is a director of the Buenos Ayres Great Southern R., and several other important companies, and was formerly an active partner in the well-known firm of accountants of Deloitte, Plender, Griffiths and Co.

Mr. William Rowed, assistant superintendent, Great Western R., at Westbury, has been appointed superintendent of the Exeter division in succession to the late **Mr. Samuel Morris.**

Mr. A. Cooper, line engineer of the "Bakerloo," "Piccadilly" and "Hampstead" tubes, has been appointed engineer also of the Met. District R. in succession to **Mr. C. A. King**, whose agreement has expired, and who has decided to practise as a consulting engineer on his own account, and in that capacity will act for the District R.

Mr. P. R. Smith has been appointed chief clerk of the General Superintendent's Department of the Caledonian R. in succession to **Mr. W. H. Potts**, who has retired under the age limit.

Captain M. Caillard has been appointed police superintendent of the Great Northern R. in succession to **Major Handley**, who has retired.

Mr. A. T. Houldcroft, carriage and wagon superintendent of the Rajputana-Malwa State R., has been appointed to a similar position on the North Western State R.

Mr. William Lang, of the superintendent's office at Exeter, L. and South Western R., has been awarded the Victoria Cross of the St. John Ambulance Brigade for jumping on to the line in front of an approaching engine and snatching a little boy, who had fallen off the platform, from certain death.

WE regret to record that **Sir Robert G. Reid**, president of the Newfoundland Rs., died on the 3rd ultimo. He was a most remarkable man and practically controlled the "transportation" in the Colony. He owned a great portion of the land, as he received 5,000 acres for every mile of railway he built.

Also that **Mr. L. G. Mouchel** died on the 27th May at Cherbourg, where he was born in 1852. By Mr. Mouchel's death the engineering profession has sustained a great loss. He was educated as an engineer in France, and subsequently settled in South Wales as a mining engineer. In 1898 he acquired the sole agency for this country of the well-known Hennebique system of reinforcing concrete, and since that time he designed, in conjunction with various engineers and surveyors, some 600 fine examples of ferro-concrete buildings, bridges and other engineering works, some of which have been illustrated in our pages. About a year ago Mr. Mouchel took Messrs. J. S. E. de Vesian, M.Inst.C.E., and T. J. Gueritte, M.Soc.C.E., France, into partnership, and also arranged that the chief members of his staff should participate in the business by forming it into a company under the name of L. G. Mouchel and Partners, Ltd.

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Change of Address.

MR. T. N. Wylie, Continental traffic manager, L., Brighton and S.C.R., has removed his offices from London Bridge to New Victoria Station.

*

Railway Safety Appliances in America.

IN our issue for last April we stated that of 495 devices or systems offered to the Block-Signal and Train-Control Board of Experts 245 had been rejected on the ground that whilst they were "safety" appliances they did not relate to signalling. By the Congress that has just been adjourned provision was made in the Sundry Civil Bill authorising the Board of Experts to investigate and experimentally test any appliances intended to promote the safety of railway working.

*

Russian Railways.

THE influence of the Russian Ministry of War in deciding the fate of projected new railways, even in districts where they are greatly needed, has just been exemplified by the case of the proposed railway between Riga, the capital of Livonia, Baltic Provinces and Kovno, the capital of the Russian Government due south of Riga. The Ministry of War has vetoed the project "from strategic reasons."

Railway construction is, however, still much talked of, and the iron industry awaits impatiently its execution, as orders are not at all plentiful. The Ministries of Ways of Communication and of Finance have just submitted to the Council of Ministers two projects: one for a railway from Odessa to Bakhmatch and the other for a railway from Vladikavkas to the Black Sea.

As was only to be expected, the employment of women as surgeons on the Russian railways has proved to be undesirable. The Minister of Ways of Communication has issued orders that henceforth no women surgeons are to be appointed either to the railways themselves or to the railway hospitals. But women surgeons will probably be appointed to attend the families of the railway officials and workmen.

*

German Railway Servants and the Public.

WITH the approach of the tourist season there arises the old question of the travelling public and the railwaymen, with whom it is brought into immediate contact. We refer more especially to the tourist who travels abroad. As is always the case, there is a charming variety of opinion as to the manners or lack of manners on the part of the foreign railway porter. Altogether we must give him, as a class, a good word; but, the demeanour of the railway porter in Prussia, for example, is sometimes very brusque and lacking in average courtesy. The General Board of the Würtemberg State railways means to set its house in order in good time, and has issued a series of suggestions for the porter's conduct in dealing with the public. The railway official is advised "to be condescending, courteous and friendly towards the general public. All officials, when greeted by a traveller, ought to return the greeting courteously, and such greetings in return are expected to be made especially by the clerks at the ticket-office windows. All questions put by travellers are to be answered with the greatest readiness. If, for example, a passenger asks about a certain train, the official must not refer him to the time-table hanging on the wall if he can answer the question straightaway. All information given to the public must be made clear and understandable."

Should any differences of opinion arise between an official and the public, then the official must maintain "a quiet, courteous and respectable demeanour even when he knows well that the traveller is quite wrong. Above all there must be no offensive remarks if the public throws doubts upon an official's correct reading of a time-table." We like the special desire for courtesy on the part of the ticket-clerk in returning greetings promptly when they are thrown at him through the window of his office.

*

Motor Railway Inspection Cars.

RAILWAY officials visiting the Franco-British Exhibition should make a point of calling at Stand No. 674 in the Machinery Hall, where two of the latest models of Motor Railway Inspection Cars, by the Drewry Car Co., Ltd., 13, South Finsbury, E.C., are shown. We have inspected these cars and think they are about the best things of the kind on the market, especially for use on long lengths of line such as exist on Colonial, Indian and foreign railways. These cars also have the additional advantage of being manufactured in this country.

One of the cars shown is arranged to seat six, and is designed to run at upwards of 50 miles an hour, so that cars on this model would be very useful on British railways where speed is essential. All Drewry's cars have a reserve which enables them to run equally well in either direction, the seats having reversible backs. Other features of the cars are 3-point suspension carrying engine and gears, Reynolds silent chain drive, automatic lubrication, multiple jet carburettor, and the engines are very accessible, and can be repaired in a locomotive shop.

*

Proposed Amalgamation of the Great Central, Great Northern, and Great Eastern Railways.

THE official announcement that Parliament is to be asked to sanction the amalgamation of the three above-named railways ought to be received with unalloyed satisfaction in East Anglia, where the Great Eastern has a monopoly. While it is true that in recent years some fast expresses have been put on and fine rolling stock has been built, the general services on the branch or secondary lines has become moribund, and on some of the joint lines is appalling, and requires general revision. Fewer, better and more convenient trains with reasonable connections with Gt. Northern trains at such points at Huntingdon are required.

*

Railway Superannuation Funds.

YET another Committee of Enquiry into Railway Affairs has been appointed by the President of the Board of Trade. This one consists of the Rt. Hon. R. K. Causton, M.P. (Chairman), Mr. G. B. Bayley, Mr. D. C. Fraser, Mr. G. S. Fry, Mr. T. Hall Hall, Mr. R. H. Selbie (Secretary, Metropolitan R.), and Mr. G. J. Wardle, M.P., with Mr. J. G. Bell, of the Board of Trade (Railway Department), as secretary, and it is to enquire into the constitution, rules, administration and financial position of the superannuation and similar funds of railway companies.

*

"The Emerald Isle, and How to Get There."

WITH the above descriptive title the L. and North Western R. Co. have issued a daintily illustrated and well-written booklet, and those who contemplate visiting Ireland for either business or pleasure should write to Euston or call at any of the N.W. receiving offices for a copy.

*

Record Tramway Traffic.

THE London United Tramways carried a million passengers on the Saturday, Sunday and Monday of Whitsuntide, half of which were carried on Whit Monday.

Books, Papers and Pamphlets.

Structural Engineering. By A. W. BRIGHTMORE, D.Sc., M.Inst.C.E. Cassell and Co., Ltd., London, New York, Toronto, and Melbourne.

It has been a pleasure to look through this book, and we wish there were more of the same class, written by men of the calibre of Dr. Brightmore, who is well known from his other works on engineering subjects, particularly in connection with waterworks, and latterly in relation to masonry dams.

There are, perhaps, quite sufficient specialised text books, such as Stoney, Ewing, Merriman, Rankine, Warren, etc., that have dealt with the steps essential to the understanding of engineering formulæ, although—goodness knows—some of them would do very well with a little more clearness of language and sequence of thought.

The book under review is one that is needed at this time, and is a work which, leaving many of the proofs and the steps to accepted text books, at once proceeds to explain how these things may be applied to engineering problems. And all this minus the danger of using formulæ without understanding, as in the case where pocket book formulas are used straight away without knowledge.

We note that Prof. Unwin has read through the proofs. By the way, why cannot that gentleman give us another up-to-date edition of his "Roofs and Bridges"?

Theory is, however, not shirked by our author, and full mathematical formulæ are given in many instances where otherwise the reading would be incomplete. Generally the book is a masterly exposition of the science of structural engineering, and is well written and comprehensive, treating as it does not only with girders, beams and roofs, but also with retaining walls, masonry dams, and reinforced concrete.

A thorough and concise treatment of bending moments and shearing stresses is given, but we note that the question of a series of moving loads, such as an engine and tender passing over a bridge, is not dealt with, and this renders the first chapter incomplete. A full consideration of solid web

stresses in a plate girder is given, and the spacing of stiffeners in such girders is effectively dealt with. We agree with the author that the rules generally given for effecting the stiffening of the webs are unsatisfactory, and if we may quote:

"If the stiffener with the help of the web on either side "of it is strong enough when treated as a strut to take the "shearing force at the section, and the web is thick enough "to transmit this as a tension to the next stiffener, there is "no fear of the girder buckling."

A full dissertation is made on cantilevers, continuous girders, and the Theorem of Three Moments, both for distributed loading and also for concentrated loads, the latter of which should always be taken in the case of continuous girders or beams of short span railway bridges. We are, however, somewhat surprised that so little reference is given to the graphic methods of working out continuous girders, such as those explained in Prof. Claxton Fidler's book on this subject. These means of graphic analysis can often be used with great advantage and ease.

The deflection of girders is the subject of an entire chapter, and the theoretical difference between the deflection of a plate girder and a braced girder is fully considered, but something might have been said as to the allowable deflection that should occur in both descriptions of girder, having regard, of course, to the comparative depth and stiffness of different cases. A knowledge of correct formula is of little service unless we know the precise use that can be made of it.

We note that the new ideas with reference to the elastic limit instead of the ultimate stress being used for the safety factor are given, and we are reminded of an often forgotten fact that, to quote again: "No advantage is gained by employing unnecessary refinement in a calculation when the nature of the case involves a certain latitude in the fundamental data."

The matter of column formulæ is dealt with much too summarily, since we have only the old Gordon-Rankine method in any way described. Nothing is said of the straight line or Ritter's methods, or the method given in the Proceedings of the American Society of Civil Engineers for the early months of the current year. Nothing is said as to the eccentric loading of columns or as regards timber strut calculations, but these are omissions that may be rectified in a succeeding edition of the book.

Arcs of circles instead of parabolas appear to be drawn in several of the diagrams, another point that can be rectified.

A description is given of Dr. Stanton's late experiments on wind pressure on roofs, including the interesting development relating to wind suction on the lee side. The minimum-maximum formulæ of Wohler, Spangenberg, Bauschinger are fully dealt with; also the latest American methods of providing for impact, etc.

One omission in the book is that there is no reference to the least work principle, a method of calculation of great use in the working out of secondary stresses and redundant members This is, of course, given at great length by Du Bois in his monumental work, but we would like to read Dr. Brightmore on this particular phase of structural work.

Arched rib bridges and suspension bridges form the subject of two chapters, full illustration being given of the method of calculating by means of "influence lines." Earth pressures, retaining walls, and foundations are dealt with in two other chapters, in which reference is made to Rankine's neglect of the value of friction at the back of the wall, and to the necessity in some cases for the consideration of the upward pressure on foundations.

A full account of the principles involved in the recent discussion on masonry dams follows, which should be of great use to anyone who has found himself unable to follow the late mathematical wrangling, and the recent reasoning from models of indiarubber, plasticine, or jelly, that have been so much spoken about. This chapter is exceedingly interesting, and should enable the engineer to dig out the truth from Trautwine's noted "heap of mathematical rubbish." Both plans of masonry dams are considered, straight and curved, and dams high and low.

The chapter on reinforced concrete is the last but by no means the least interesting chapter in the book, and full instructions are included for proportioning both the concrete and the steel reinforcement in beams, columns, floors, roofs, and foundations.

The book throughout is exceedingly well got up in every way, the diagrams being excellent, the writing and formulæ very clear, the type and binding all that can be desired. It should have a prominent place in the library of every structural engineer.

*

Manual of Recommended Practice for Railway Engineering and Maintenance of Way, containing the definitions, specifications and principles of practice adopted and recommended by the American Railway Engineering and Maintenance of Way Association. 1907.

The constitution of the American Railway Engineering and Maintenance of Way Association says, "The object of this Association shall be the advancement of knowledge pertaining to the scientific and economical location, construction, operation, and maintenance of railroads." The means to be employed for this purpose shall be as follows:—Meetings for the reading and discussion of papers and for social intercourse: the investigation of matters pertaining to the objects of this association through standing and special committees: the publication of papers, reports and discussions: the maintenance of a library. It has sixteen standing committees, which deal with the following subjects:—Roadway: Ballasting: Ties: Rail: Track: Buildings: Wooden Bridges and Trestles: Masonry: Signs, fences, crossings and cattle-guards: Signalling and interlocking: Records, reports and accounts: Uniform rules, organisation, titles, code, etc.: Water service: Yards and terminals: Iron and steel structures: Economics of railway location. Then there are at present special committees on classification of track and on a uniform general contract form.

These committees have from time to time recommended a standard practice for the department they deal with, and in the volume now before us these recommended practices are all recorded, together with definitions, specifications and sketches, diagrams and plans. This record cannot fail but to be of great value to all in America that are associated with the construction and maintenance of railways and allied engineering departments, and we do not doubt that officers in other parts of the world would find the book instructive and interesting.

*

The Strength of Chain Links. By G. A. Goodenough and L. E. Moore. Bulletin No. 18 of the Engineering Experiment Station of the University of Illinois.

This pamphlet is a record of a series of experiments on chain links and circular rings made, during a period of two years, for the purpose of confirming or disproving a theoretical analysis of the stresses in links and rings. A comparison of calculated and measured distortions affords the desired test. The result of the experiments is a complete confirmation of the analysis. Having a reliable theory, the bending moments and maximum stresses are calculated for links of various forms, and the results of such calculations are applied to the formulas for the loading of chains given by Unwin, Bach and Weisbach. It is shown that the usual formulas for chain loads give maximum tensile stresses of 33,000 to 40,000 lb. per sq. in., and maximum compressive stresses of 60,000 lb. per sq. in. New formulas for safe loads are proposed. The bulletin is concluded with four appendices giving in full the theoretical discussion, which is the basis of the experimental work.

This bulletin will be of special interest to all engineers and manufacturers who are concerned in any way with hoisting and transmission. Copies may be obtained upon application to the Director, Engineering Experiment Station, Urbana, Illinois.

RECEIVED.

Handbook on Railway Surveying for Students and Junior Engineers. By B. Stewart. London: E. and F. N. Spon, Ltd., 57, Haymarket. New York: 123, Liberty Street. 1908. [128 pp.; 6½ by 4⅛; price, cloth, 2s. 6d. net.]

Tests of Concrete and Reinforced Concrete Columns, and *Tests of Cast-Iron and Reinforced Culvert Pipe*. By Arthur N. Talbot. Bulletins Nos. 20 and 22 of the University of Illinois Engineering Experiment Station, Urbana, Ill., U.S.A. [60 and 66 pp. respectively; 9 by 6; gratis.]

Tests of a Liquid Air Plant. By C. S. Hudson and C. M. Garland. Bulletin No. 21 of the University of Illinois Engineering Experiment Station. [20 pp.; 9 by 6.]

Westinghouse System of Heating Railway Carriages.

The Westinghouse Brake Co., Ltd., hold the patent rights, and are now introducing to railways in this country the system of Heating Railway Carriages that has been in use for some time on various Continental railways, and of which some 4,000 sets are in use or on order. It is an automatic system, of which the details are simple, and which has, we understand, given every satisfaction in operation. Its distinctive features are that:—

The steam in the apparatus is at atmospheric pressure only; there is therefore no risk of bursting, and the joints do not require to be made with any particular care.

The steam is mixed with air and the circulation is automatically continuous, and the desired temperature of the radiators is also automatically maintained constant, so that the carriages near the engine do not get hotter than those in the rear of the train.

As the steam is completely condensed in the heating circuit only a minimum quantity is used. The apparatus effectually drains itself, and thereby all risk of freezing is obviated.

The system will work with any other system using a main steam train pipe, as any standard coupling can be adopted.

Fig. 1 shows the arrangement of the system on an eight-compartment coach. The main pipe is 1½ to 2 in. diam., and falls from either end to a separator and steam trap ST, and near which there is a Tee-piece TP, from which, at the top, in order that the steam may be as dry and clean as possible, a ½in. branch, provided with a strainer, is taken off and led through an isolating cock, IC, which is worked by rods from either side of the coach, to the injector I on fig. 1, and shown in section by fig. 2, which is the principal fitting of the system and which the branch pipe enters at A.

The steam, when it arrives at the entrance to the injector fitting, has a pressure of about 40 lbs. per sq. inch. It passes through the passage B past the valve V, which is then fully open, to the injector C and draws air through the pipe E, which is open to the atmosphere at M, and enters, mixed with air and with increased velocity, the delivery pipe at D. This pipe is 1in. diam., and from it ¾in. branches lead, through compartment valves, CV, fig. 1, to the radiators, R, in the compartments.

The radiators fall in the usual manner towards the return exit for the steam, air and water, and which is at the lowest point. The return branches, ¾in. diam., falls to the injector fitting, which it enters at F. The return air and steam rise through G to the chamber H, whence they are drawn by the injector C and returned to the delivery pipe. The water of condensation drains through L to the outlet at M.

As the steam and air mixture passes through the chamber H it impinges on the thermostatic tube K, which expands or tends to straighten under the increased temperature. But as one end of K is rigidly fixed to the case by the bolt J the other end of the tube presses against screw S in the end of the valve V, which closes. By means of the screw S the valve may be adjusted to close at any desired temperature up to 212° F. In practice the valve V seldom quite closes, but when the circuit is warm remains sufficiently open to allow just the quantity of steam to pass to maintain the predetermined temperature. Should, however, the valve close completely the steam remaining in the circuit condenses and cold air enters at M, fills the chamber H, cools and contracts the thermostatic tube, and opens the value V and re-admits steam.

The steam trap and separator, fig. 3, is inserted in the main pipe. So long as the pipe is cold the steam trap, the valve in which is controlled by a thermostatic tube as above described, is open to the atmosphere, and any water can drain away. When steam is admitted the valve closes until water collects and the tube cools and re-opens the valve. The steam trap on the delivery pipe operates in the same way to clear that pipe of water of condensation.

The compartment valves CV, fig. 1, are worked by the passengers. The usual handle is provided above the back-

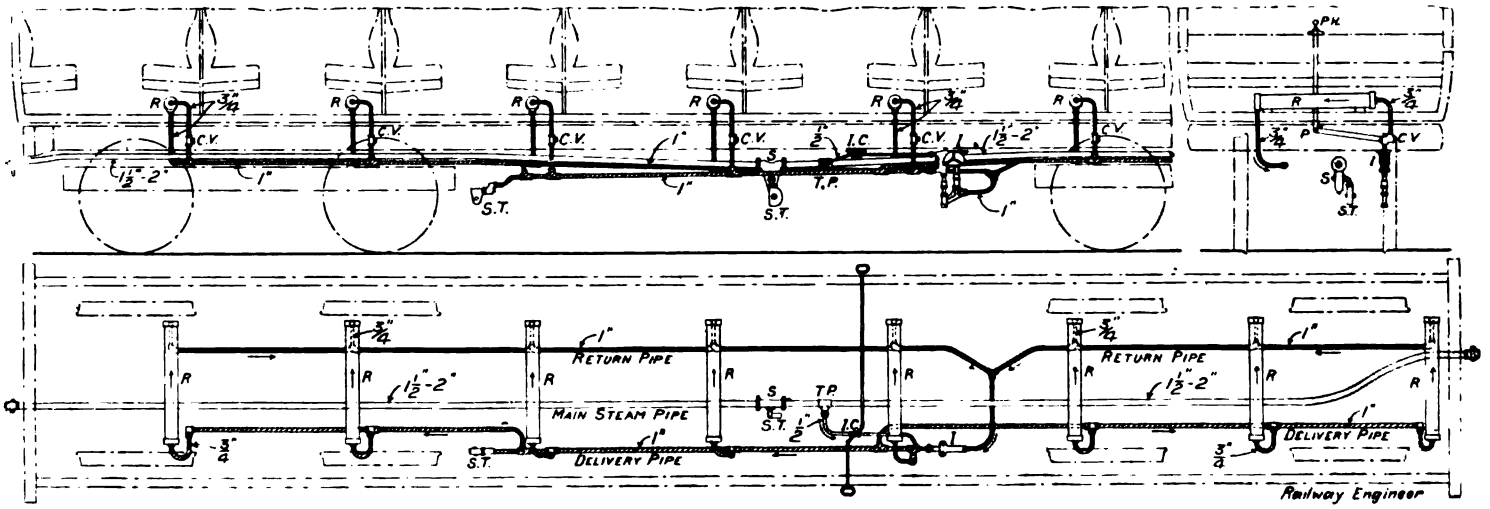


Fig. 1.

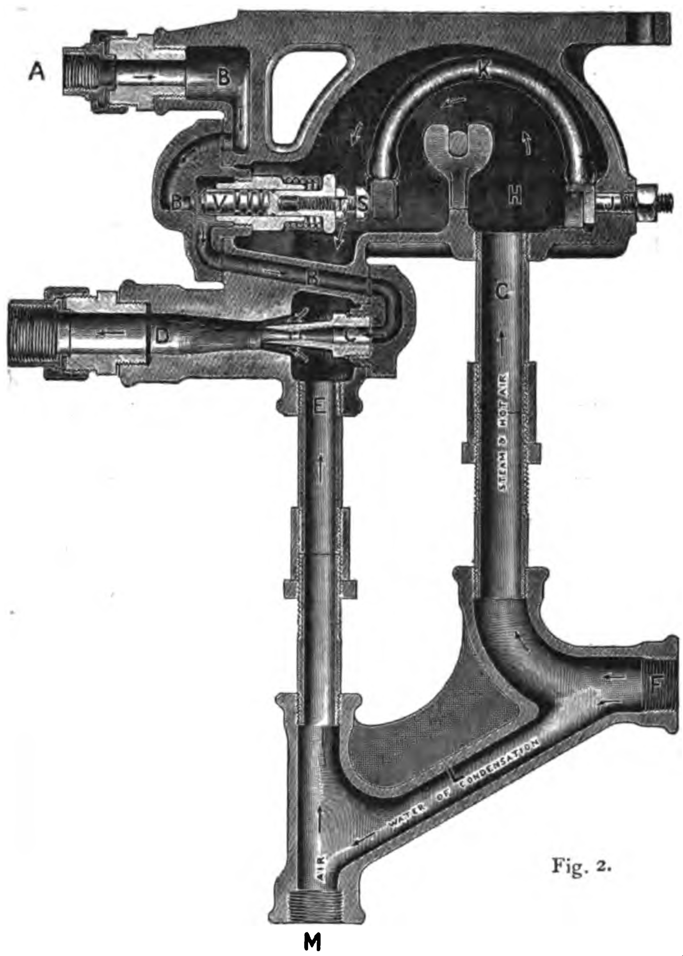


Fig. 2.

squab, as at PH. The motion of the passengers' handle is communicated to the compartment valve by means of a wire cord and grooved guiding pulleys. The cord, which is about $\frac{3}{32}$ diam., is provided with a right and left-hand straining screw. It is prevented from slipping by being passed through two holes drilled with one of the flanges of the pulley on the spindle of the compartment valve, which is of

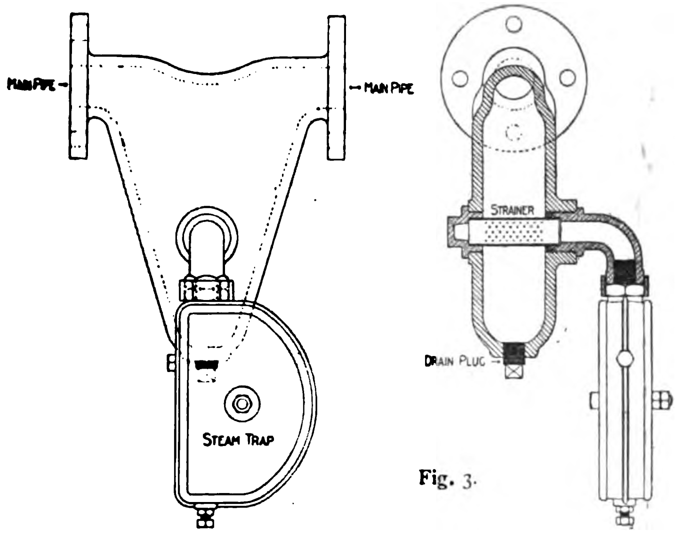


Fig. 3.

the lifting type, and is operated by a cam on the above-mentioned spindle.

The compartment valve case also includes a regulating valve which prevents the steam "short circuiting" through the first two or three radiators in the heating circuit. These valves are adjusted when the carriage is fitted up so that all the radiators rise to the same temperature, and the valves are then fixed, and they do not require to be altered again unless their position on the carriage be changed.

In conclusion, we may say that the Westinghouse Brake Co., Ltd., London, have issued a well-illustrated pamphlet which contains further information as to the fitting up of the system and a more detailed description of some of the fittings.

Notes on Locomotives.

A NOTICEABLE feature in many designs of recent locomotives is the evident desire to improve by every and any means the efficiency of the machine as a whole, this object is being sought after in various ways, by improving the quality and properties of the steam by superheating, which is now receiving serious attention on several British railways, including the Brighton, the Lancashire and Yorkshire and the Gt. Western; secondly, the heating of the feed water is again attracting attention both in this and other countries, while the advantages of multicylinders seems to have firmly established themselves, also compounding in many quarters is gaining ground.

The latest type of engine on the L., Brighton and S.C.R. is of more than ordinary interest, because, apart from the fact that these engines are very heavy, and although fitted with tanks are intended for express traffic, they combine in themselves two of the sources of improved efficiency above mentioned, namely, *Superheating and Feed-water Heating*. The former is of the smoke-tube pattern now almost universal; the latter is carried out on the principle of utilising the heating of the exhaust steam; in this case branch pipes are fitted at the base of the blast pipe which conduct some of the exhaust steam to the tanks, where it is condensed. The hot water is taken from the tanks by special float pipes and fed to the boiler by pumps worked off the crossheads.

The principal dimensions of these engines are: Cylinders, 19ins. x 26ins.; piston valves, coupled wheels, 6ft. 9ins. diameter; boiler heating surface, 1,625 sq. ft.; area of grate 24 sq. ft.; working pressure, 180 lbs.; weight in working order, 73 tons; tank capacity, 2,110 gallons.

Another instance of *Feed-water Heating* is to be found in Gt. Britain, on the L. and South-Western R., where the question is being seriously tackled by Mr. Drummond. As in the previously described engines the exhaust steam is used for heating, only with this great difference, that it does not come into direct contact with the feed-water. The method adopted is as follows: The usual well of the tender tank is closed and fitted with a tube-plate at each end and a number of longitudinal tubes through which the steam flows; the exhaust steam flows from front to rear giving up its heat; the feed-water enter the trough at the back end and is sucked forward by the feed pumps. The pumps are on the engines and are of the duplex steam type.

An absolutely distinct method of *Feed-water Heating* from the two above described has been brought out by Mr. Trevithick, of the Egyptian State R. In this arrangement the water from the tender is pumped into the boiler by a duplex steam pump, the exhaust from which is utilised as a first stage, thence the water is circulated through two cylindrical tubular heaters heated by exhaust steam from the cylinders, after which the water passes into the final and principal heater, in which the spent gases from the tubes are utilised for heating. The heater consists of an annular drum placed in an extension of the smoke-box; the gases are constrained by lining plates to pass through the middle space of the ring and thence through the tubes of the heater to the outer case of the smoke-box and so to the chimney—a very considerable degree of reheat being obtained.

In America also, on the Central RR. of Georgia, feed-heating is being tried with success, the design in use resembles that of Mr. Trevithick in principle, excepting that the drums heated with exhaust steam from the cylinders are not used, also that the final or smoke-box heater consists

of two batteries of tubes, one arranged on each side of the smoke-box in a manner similar to the Baldwin steam heater described in our issue of April, 1907.

As regards *New Types of Engines*—considering Gt. Britain—the most important design brought out have been tank engines; of these we have already mentioned the L., Brighton and S.C.R. engines. An entirely new type has been put to work on the North-Eastern R., having six coupled wheels, a four-wheeled bogie and inside cylinders. These engines have been built to work the passenger traffic over the difficult coast line of Yorkshire through Whitby. The cylinders are fitted with piston valves and drive the leading coupled wheels; the boiler has a round-topped firebox; the water is carried in side tanks. The principal dimensions are: Cylinders, 18ins. × 26ins.; diameter of coupled wheels, 5ft. 1½ins.; bogie wheels, 3ft. 1¼ins.; rigid wheel-base, 12ft. 6ins.; total wheel-base, 26ft. 3ins. The boiler has a total heating surface of 1,312 sq. ft., the fire-box heating surface is 130 sq. ft., the grate 23 sq. ft., the total weight in working order is 69 tons, adhesion weight 52 tons, tank capacity 1,500 gallons.

The Lancashire and Yorkshire Railway has just put into service a series of 0-8-2 tank engines, which in point of power and weight rank second only to the 3 cylindered engines of the Gt. Central R., the cylinders are inside the frames and are 21½ins. × 26ins., the coupled wheels are 4ft. 6ins. diameter, the side tanks have a capacity of 2,000 gallons and in working order the total weight is 84 tons.

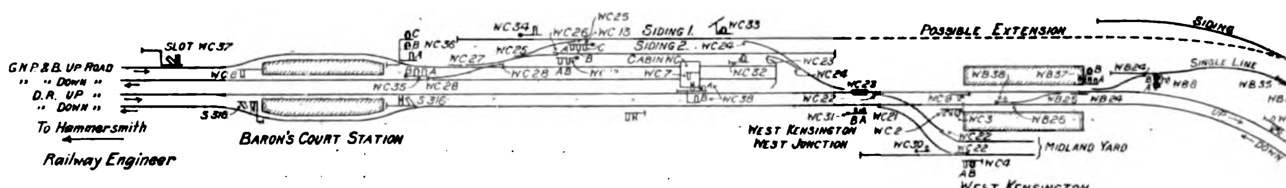
The 4-6-2 type of engine, which is represented in this country by the "Great Bear" on the Gt. Western R., is also at work on the Paris-Orleans R., where some very fine four cylindered compounds are doing excellent service. Their principal dimensions are: cylinders, 15⅝in. × 25½in.; l.p. cylinders, 25⅝in × 25½in.; diameter of coupled wheels, 5ft. 10in.; rigid wheelbase, 12ft. 9ins.; total wheelbase, 34ft. 5in. The boiler is of exceptional proportions, having a total heating surface of 2,769 sq. feet, and a grate area of 45.9 sq. feet. This large grate is obtained by extending the rear portion of the firebox laterally to a width of 6ft. 10⅝ins., the grate is, practically speaking, divided into three lengths, the front being normal width, the back as above, the middle section inclined to join front and rear. The working pressure is 227lbs. In working order the weight is 89 tons 10 cwts., the adhesion weight is 52 tons.

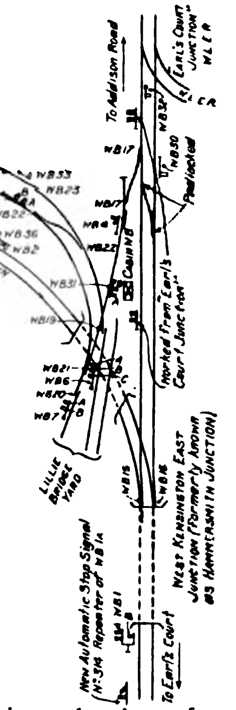
The annexed table gives the comparative dimensions of the two 4-6-2 types:—

	Great Western Railway.	*Paris-Orleans Railway.*
Cylinders	4 H.P. 15 in. × 26 in. ...	2 H.P. 15⅝ in. × 25½ in. 2 L.P. 25⅝ in. × 25½ in.
Coupled Wheels ...	6 ft. 8½ in.	5 ft. 10 in.
Boiler Heating Surface	3,400 sq. ft.	2,769 sq. ft.
Boiler Grate Area ...	41·7 sq. ft.	45·9 sq. ft.
Boiler Pressure ...	225 lbs.	227 lbs.
Weight Full, total ...	96 tons	89 tons 10 cwt.
,, adhesion	60 tons	52 tons.

The first batch of the heavy goods engines built by outside makers for the North Eastern R. has been delivered by the North British Locomotive Co., a total of 50 engines has been ordered, the various makers being the above named firm, 20 engines; Beyer, Peacock and Co., 20 engines; R. Stephenson and Co., 10 engines. These engines are of the plain six wheels coupled type, but are of very heavy proportions, the cylinders are 18½ins. by 26ins., the coupled wheels 4ft. 7¼ins., the weight in working order is 82 tons. We intend to refer to these engines again in our next issue.

Signalling at West Kensington; Metropolitan District Railway.





THE new signal box at West Kensington East Junction (opened on the 31st May last) completed the re-signalling of the District R. in connection with the conversion of their line from steam to electric traction.

The annexed diagram of the lines and signals shows that there are two boxes at West Kensington. The West Box controls Baron's Court Station and the west end of West Kensington, the G.N. Brompton and Piccadilly Tube, the sidings to and from the G.N.B. and P.R. and the Midland R. coal-yard. The East Junction box controls the east end of the West Kensington station, the branches to and from Lillie Bridge Yard and the junction with the lines to and from Addison Road.

The East Junction Box is situated in Lillie Bridge Yard and so is some distance from its work, but no disadvantages are experienced therein owing to the use of "Track-Circuits." These are employed throughout and extend up to the boundary at the Earl's Court Junction of the West London Extension R. Owing to the single line between West Kensington and Lillie Bridge Yard having been equipped with "Track-Circuits" the safety of trains is secured without the presence of the pilotman, who has been withdrawn.

Each Box contains 30 working and 9 spare levers. The West Box does the work of 50 mechanical levers and the East Box of 47. They replace three mechanical boxes.

There is a considerable number of irregular movements here, such as over the facing road. These are provided for in the working regulations and this fact accounts for the large number of slotted signals, all of which are controlled by "Track-Circuits" and so "hold the road."

The new arrangements permit for a minute headway for trains over each road, and the existing service often provides for four trains in as many minutes.

The whole scheme is a very "tricky" one and has been carried out under very trying conditions. The materials were supplied by the Westinghouse Brake Co.—now associated, for signalling, with the McKenzie, Holland and Westinghouse Power Signal Co.—and the work was carried out by the District R. Co.'s own staff under the supervision of Mr. Chas. A. King, the late engineer, and Mr. B. H. Peter, the signal engineer.

Hadfield's Stone Breakers.

In connection with some articles on Modern Permanent Way we shall shortly publish, the following illustrated descriptions of the machines and plant made by Hadfield's Steel Foundry Co., Ltd., Sheffield, for breaking stone for ballast will be useful. Hadfield's make two types of machines, viz., the Toggle Joint Nipper and the Gyratory.

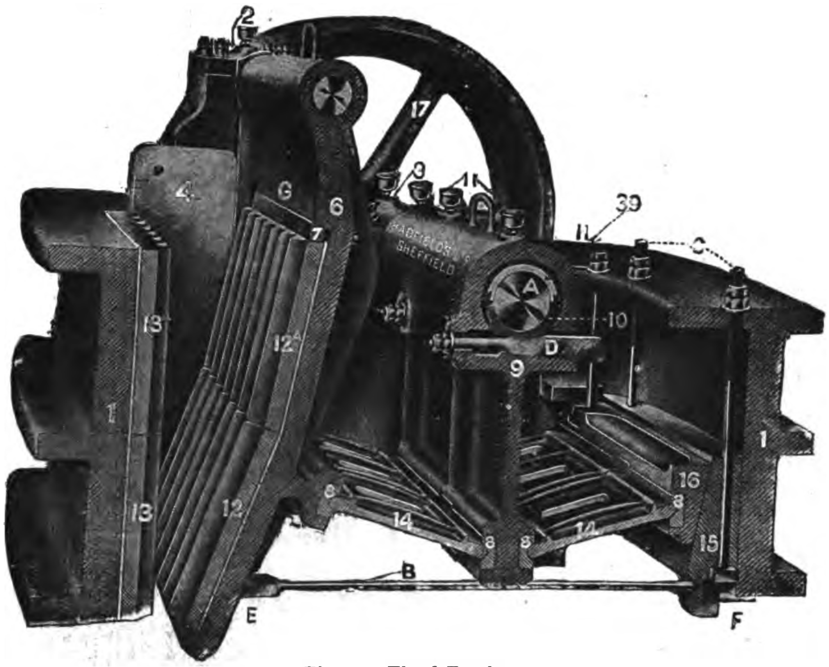


Fig. 1.—Fixed Breaker.

Fig. 1 is a sectional perspective view of Hadfield's patent toggle joint stone-breaker. A is an eccentric shaft driven by belt pulley attached to the fly-wheel 17, which raises and lowers the cast steel "pitman" 9, at the foot of which are the toggles 14, resting in the cushions 8,8,8,8. The stone to be broken is placed in the hopper on the left. On each narrow side is a cheek plate 4 and on the left is the fixed jaw face 13,13A and on the right are the lower swing jaw face 12 and upper swing jaw face 12A. These jaw faces and the cheek plates are made of "Era" manganese steel. The jaw faces are of a patented design, and whilst being of ample strength they are much thinner than is permissible with chilled cast iron. The size to which the stone is to be broken is determined by simply raising or lowering the adjusting wedge 15 (by means of the bolts C,C), which varies the position of the toggle block 16. The swing jaw face hinges on the shaft at the top of the machine, and as the eccentric shaft A is turned the "pitman" 9 is raised and lowered and the toggle straightened. The stone is broken between the fixed and swing jaw faces and passes to the screens.

Fig. 2 is a sectional perspective view of the Heclon gyratory stone-breaker. The fixed portion consists of the bottom shell *A*, on which rests top shell *N*, surmounted by the hopper M. The concaves *O*, made of "Era" manganese steel, form the lining of the top shell *N*. The centre spindle *I* supports on a ball *P* the hollow coned shaft *T* so that it is free to move. The cast steel centre *R* is fixed to the shaft *T*, and carries the mantle *S*. At the bottom of the shaft, and inside it, is an eccentric *G1* cast on the bevel wheel *G*, driven by the pinion *H* on the counter shaft 3 driven through the pulley *J*.

Stone being placed in the hopper is gradually broken. The motion is least at the top and consequently there is less shattering of the stone and the dust is minimised. The method of adjustment is very simple and is accomplished by raising or lowering the spindle by means of the worm F and worm-wheel *E*. A safety device is provided to guard against a hammer, drill or crowbar, that may have accidentally fallen into the hopper, damaging the apparatus.

The wearing parts are all made of "Era" manganese steel, and a striking feature of the design is the hollow steel driving shaft which gives great strength, and also enables the eccentric to be entirely shielded from dust.

By the courtesy of the Hadfield Co. we are also able to give details of a large stone-breaking plant which they have recently supplied to a foreign railway, not the least interesting feature of which is the fact that the whole of the machinery is electrically driven.

Fig. 3 is a sectional end elevation. The stone is brought from the quarries by means of a light railway in small double-side tipping wagons, and tipped into the mouth of the breakers on the right of the illustration. The size of the breakers, which are of the fixed type, is 30in. × 18in. They are driven by a 11in. wide belt from a 90 B.H.P. electric motor making 480 to 500 revolutions per minute, while the breaker makes from 244 to 250 revolutions. As the stone is crushed, and before screening, it falls through a shute direct on to an elevator of the continuous bucket type. The

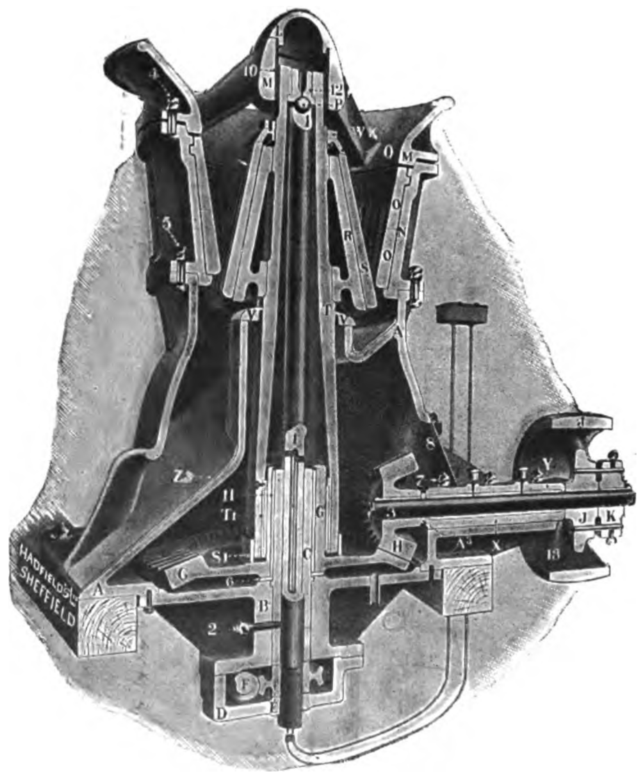


Fig. 2.—Heclon Gyratory Stone Breaker.

elevator is 18in. wide, has chains of "Era" manganese steel, and works over sprocket wheels of the same material, and which are 68ft. apart. It travels about 120ft. per minute. The elevator is driven by a 9in. wide belt from

from 110 to 114 revolutions per minute. The elevator has a capacity of 30 tons per hour.

The introduction of belts between the motors and machines has been found to have a cushioning effect and to equalise the load on the motors.

The stone being broken to about $2\frac{1}{2}$in. cube the buckets drop it direct into the screen in order to clean it of dust. The screen is driven by a 10in. wide belt from a 15 B.H.P. electro motor which has a speed of from 480 to 500 revolutions per minute, and the pulley on the screen is 4ft. 8in. diam.

Each screen is 10ft. long and 3ft. $10\frac{1}{2}$in. diam. They have a speed of about 16 revolutions per minute. The dust falls

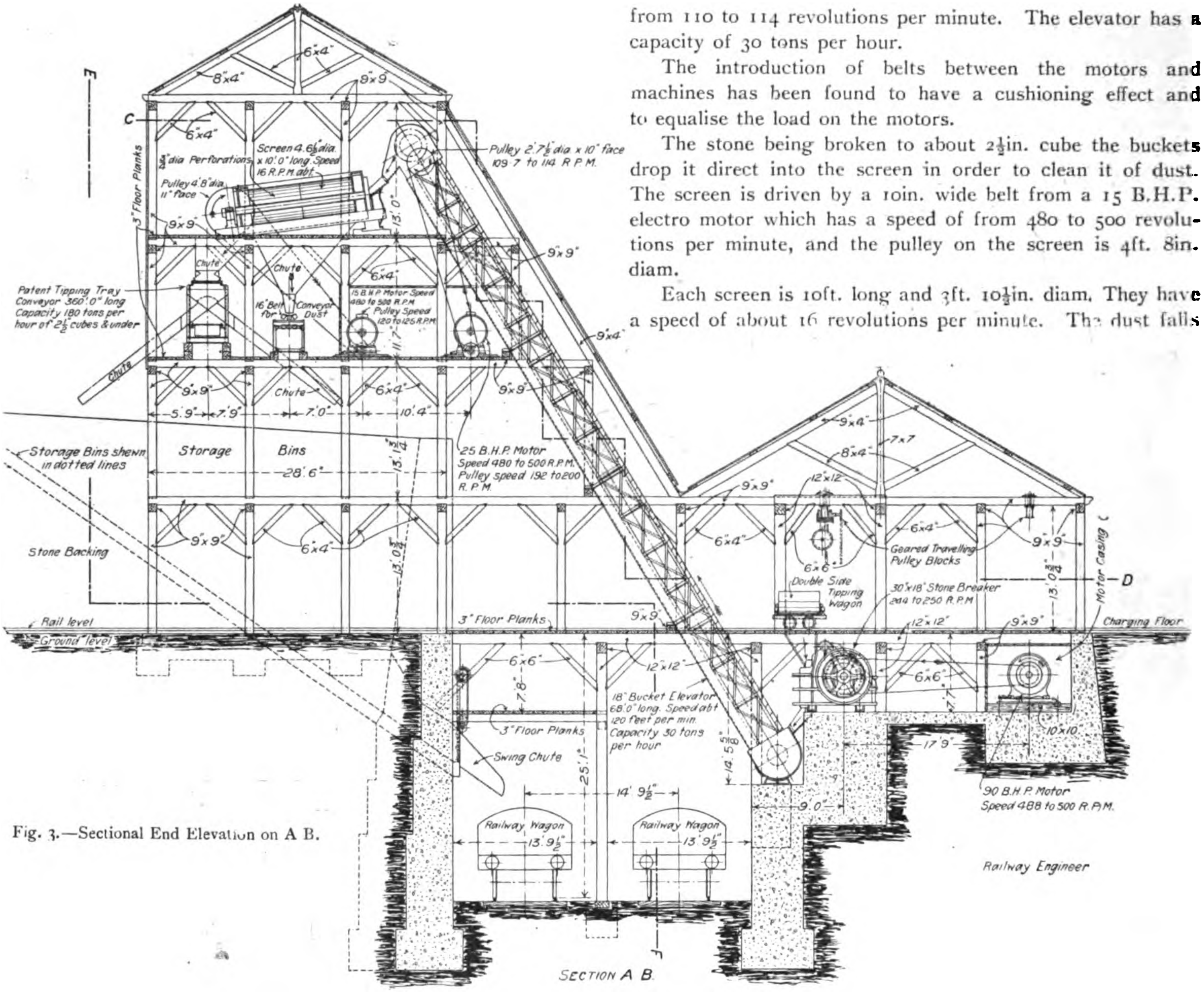


Fig. 3.—Sectional End Elevation on A B.

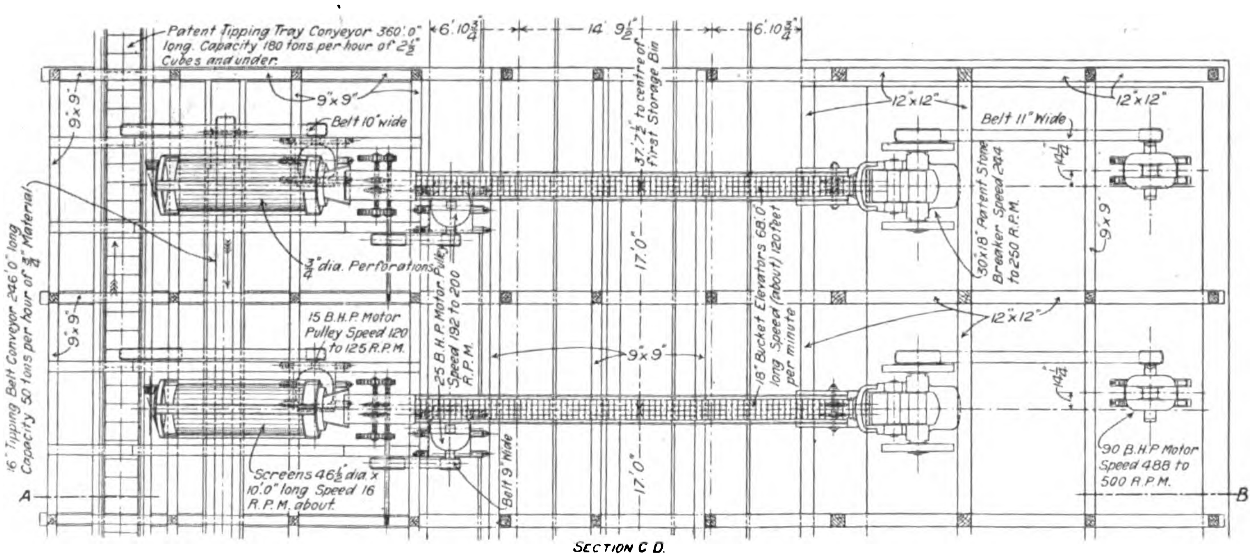


Fig. 4.—Sectional Plan on C D.

a 25 B.H.P. electro motor which has a speed of from 480 to 500 revolutions per minute. The pulley at the head of the elevator is 2ft. $7\frac{1}{2}$in. diam. and travels at a speed of

on to a tipping belt conveyor 16in. wide and 246ft. long. It is driven by a 25 B.H.P. motor with a pulley speed of from 480 to 500 revolutions per minute. This is fixed on the right

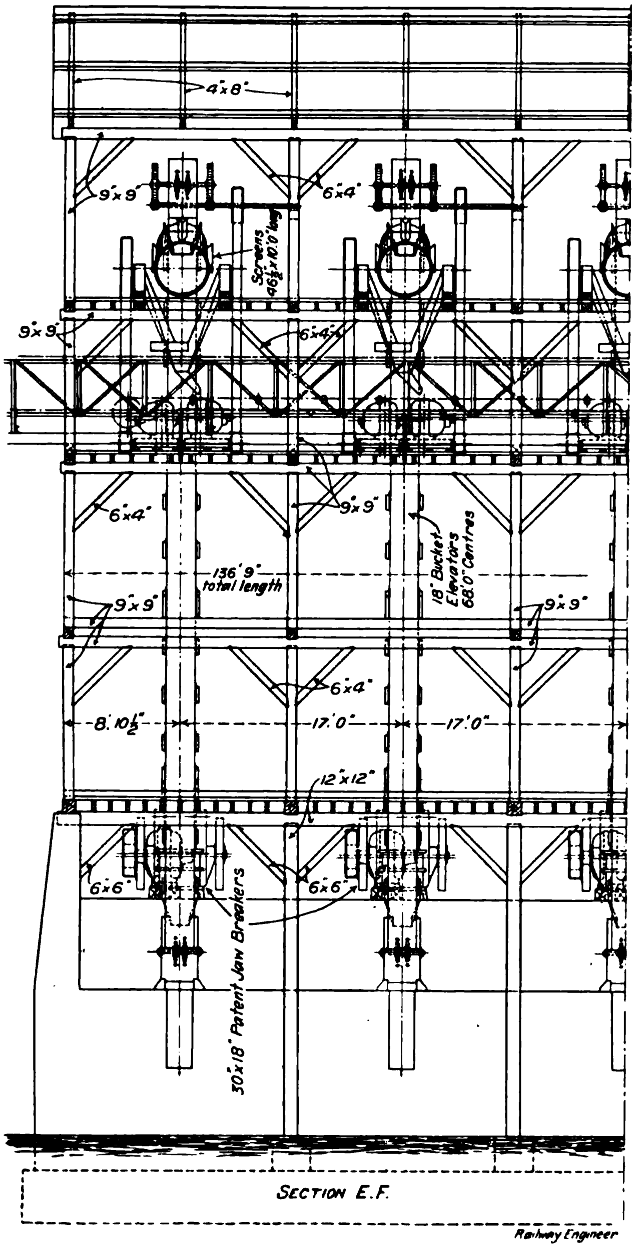


Fig. 5.—Sectional Side Elevation on E F.

side of the plant—see fig. 7—and the conveyor has a capacity of 50 tons per hour of ¾in. material, which is deposited in three large bins.

The 2¼in. stone falls out of the screen through a shute on to a patent tipping-tray conveyor 360ft. long and capable of taking 180 tons per hour. It is driven by a 25 B.H.P. motor, fixed at the other end—the left—of the plant, and having a pulley speed of from 480 to 500 revolutions per minute. The material is deposited in 7 bins. The tipping carriage on the conveyor is provided with chutes on either side so as to more evenly spread the distribution and it can be moved from bin to bin.

The material is released from the bins direct into wagons on the railway through bin gates 36in. × 36in.

Fig. 3 also gives details of the timber structure holding the plant. Fig. 4 is a sectional plan showing, on the top of the drawing, the stone-breakers and, at the bottom, the screens and the conveyors to the dust bins on the right and to the storage bins for 2½in. stone on the left. The elevators are in the middle. The plant comprises eight complete breaking sets served by two common conveyors, one for ¾in. material and one for 2½in. stone as described above.

Fig. 5 is a sectional side elevation, and fig. 6 gives on the left a sectional elevation of the stone storage bins and conveyor and, on the right, of the dust storage bins and conveyor. Fig. 7 is a general plan of the installation.

The total output of the plant is at the rate of 4,500 tons of ballast per day.

The Collapse of the Quebec Bridge.

We do not propose to give an exhaustive account of this remarkable disaster, which probably is unparalleled in the history of engineering, as the whole matter has already received full attention in the technical press, especially in the American journals.

The bridge was a huge cantilever erection over the St. Lawrence river of 1,800 ft. central span (see fig. 1), and whilst building, one half (the Southern portion) of the structure collapsed on August 29th, 1907, the loss of life being 70 out of 86 men who were working on the bridge at the time, many of those not killed being more or less seriously injured. About 40,0000 tons of steelwork, it is said, were precipitated into the river, and an expenditure of about £500,000 was rendered useless.

An elaborate and exhaustive report, consisting of over 1,000 pages, and including no less than 19 appendices, has been issued by the Royal Commission of the Canadian House

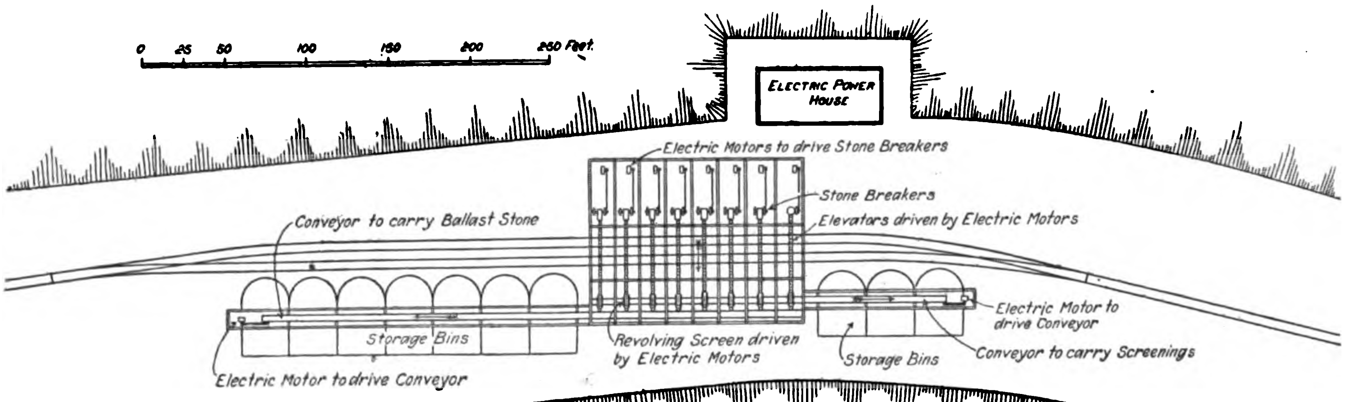


Fig. 7.—General Plan of Stone Crushing Plant for Railway Ballast.

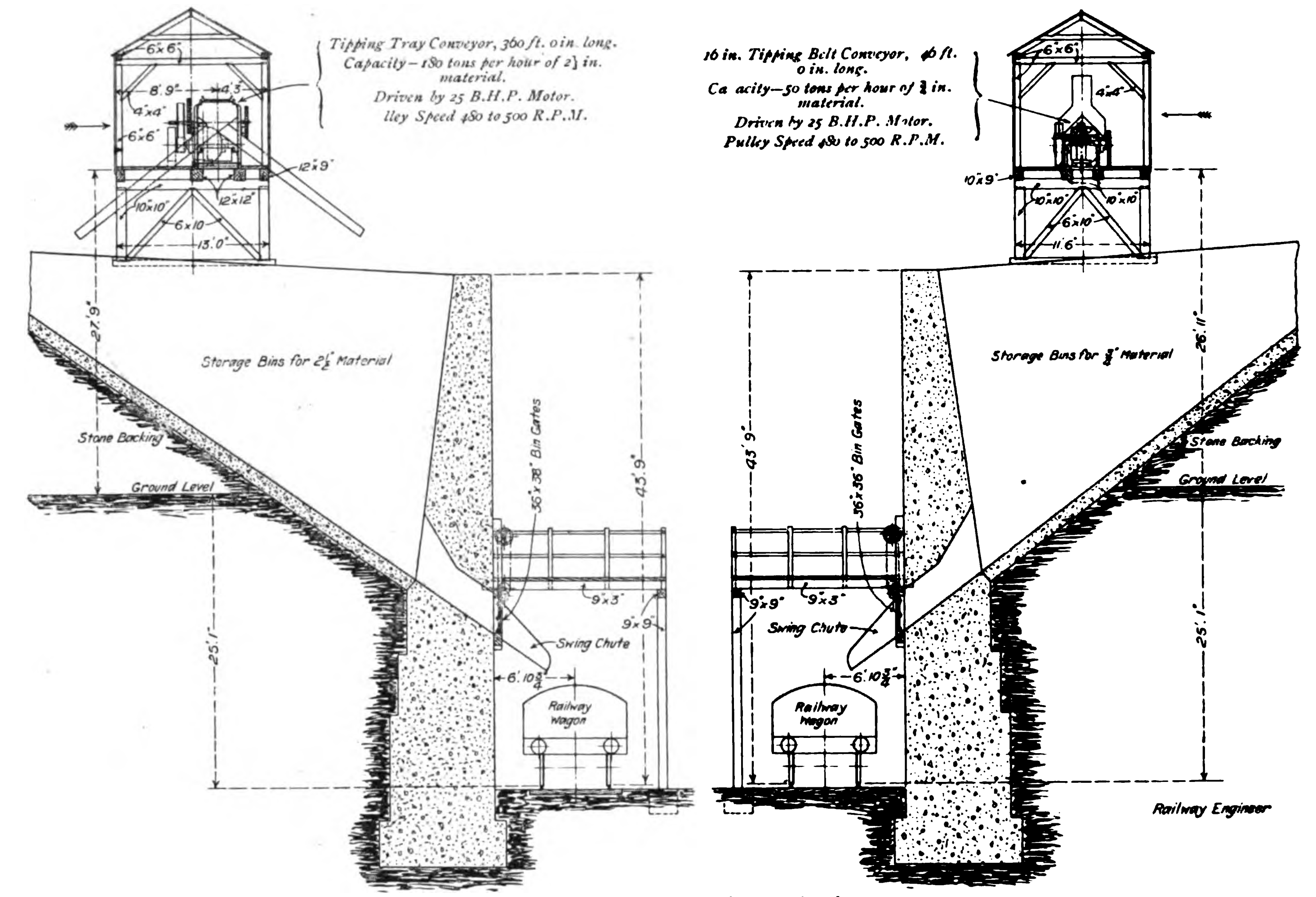


Fig. 6.—Storage Bins ; Hadfield's Stone Breakers.

of Commons. These appendices deal with every conceivable aspect of the question, even going so far as to enquire into the life history of most of the principal men who were in any way implicated in the work. Tables and data are given on every conceivable matter, even as regards the weather and wind conditions for several weeks preceding the collapse, though what this has to do with the question is not apparent at first enquiry.

The report states that failure took place in the compression member X, fig. 1, which was found, after the collapse of the bridge, to be doubled up, presumably from end pressure, into the shape of the letter S.

The segment of the chord referred to was 57 ft. long, and was composed of four vertical flitches or series of plates placed side by side with spaces between, fig. 2, each of these flitches being made of several plates riveted together to the composite thickness of 3½ ins. The width of these plates, which of course becomes the depth of the chord, was 4½ ft., and the respective flitches were spaced in such a way as to make up a boom 5½ ft. in horizontal width, the different flitches being connected together in what has proved to be a very inefficient manner by angle iron diagonal bracings on the upper and lower surfaces of the boom. They were attached to the vertical flitches by some small amount of riveting, and the chord when completed forms one link in a chain of such chords, connected together by means of the ordinary American pin joints.

It is obvious that the lateral stiffness of such a composite flitch is much less, even when the plates are riveted together, than that of a solid plate of the aggregate thickness, and it is also plain that there is nothing to aid in the stiffness of the flitch against buckling, other than the light angle in bracing referred to, except some very doubtful gussets placed between the different flitches. Further, with the use of the pin joints the ends of the chord segment were not encastré or fixed in any way, and it may also be noted that in consequence of the general design the end pressures were always applied in an oblique direction.

After the finding of the Commission it is, of course, impossible to say that the cause of the collapse was anything else than the failure of the bottom chord member of the shore cantilever arm at X.

But with the finding of the Report on other details perhaps some exception may be taken.

It is very plain that the disaster was not due to accident or to anything abnormal in the weather conditions, and in this respect the case is analogous to the remarkable failure of the Charing Cross Station roof.

The report is that the failure was due to an error of judgment, or in other words, to defective design; a finding that is, of course, perfectly obvious. But when the report goes on to say that the error of judgment was not due to lack of common professional knowlege, neglect of duty, or to a desire to economise, it seems reasonable to enquire a little further into the significance of the error of judgment referred to.

The consulting engineer engaged on the work was the famous Mr. Theodore Cooper, and the engineer who actually

made and carried out the design was Mr. Szlapka, of the Phœnix Bridge Co. The ultimate responsibility, of course, rests with the former, at least in theory, although practically the latter has received the major part of the censure, at least for the time.

It seems to be assumed that if Mr. Theodore Cooper had been a younger man, and had received more sufficient remuneration, and had more time at his disposal, that the compression member which failed would have been properly designed and able to do its appointed work; whilst at the same time it is also assumed that the actual designing engineer, Mr. Sylapka, found the matter of designing the strut in question beyond his ability.

We cannot, however, find that Mr. Cooper in his evidence gives any indication of the point where the calculation made by Mr. Sylapka for the unfortunate member was at fault; and in fact, when reading through the long Appendix 16, which gives an account of all the lattice column formula known at the time the design was made, we fail to find any sufficient formula which this engineer could have used to better effect. We quote as follows:

> "The experience of the Commission is practically the same as that of Mr. Szlapka, for, except the rule in 'Modern Framed Structures,' all the information we have been able to find has appeared in the periodical press since the collapse of the Quebec Bridge."

Why, then, accuse Mr. Szlapka of want of ability? and why assume that Mr. Cooper or any other engineer could under such circumstances have done better?

The Commission deplore the lack of full size compressive tests, and they themselves had to have a model made to ⅓ full size to prove the correctness of their own empirical reasoning.

Should Mr. Szlapka have had a model made in a similar way? Could he have done this for every member of the structure before he had issued the working drawings?

There is no doubt but that the designing engineer made use of all available formula in designing the member, and that he could no more lay his hand upon information relating to full size column experiments than the commissioners themselves could.

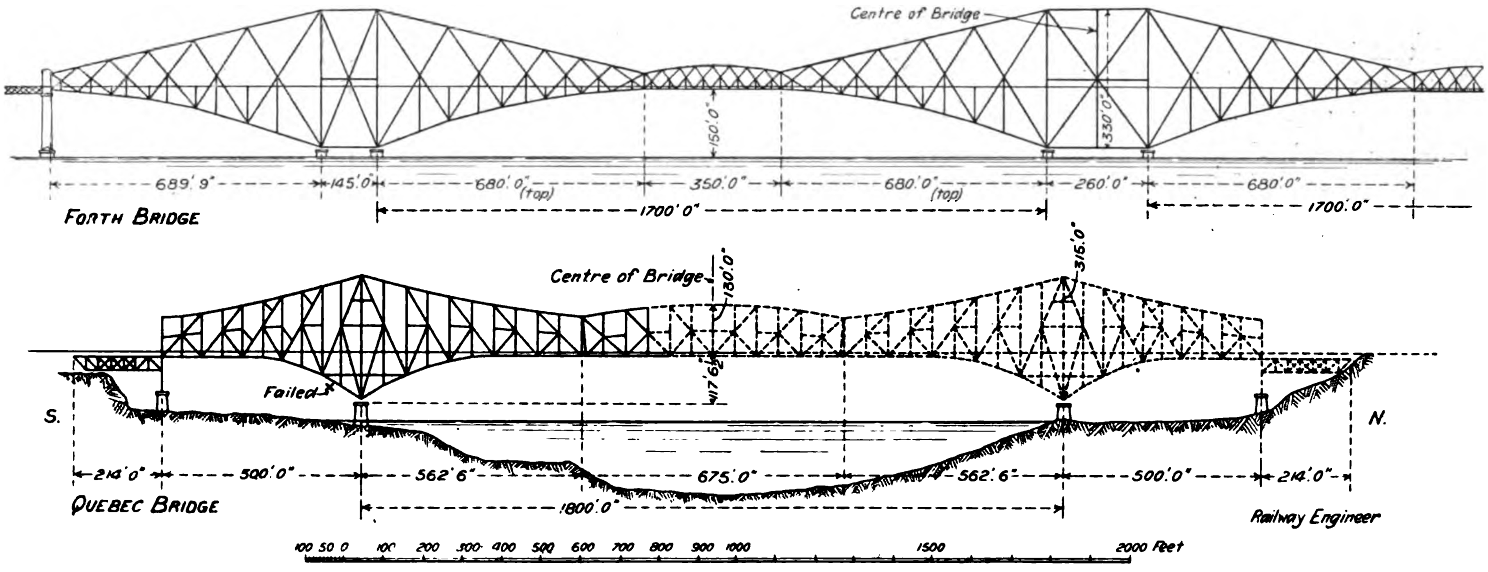


Fig. 1.

Then where is the heinousness of his sin, what is the precise burden that the scapegoat is to carry away with him to the wilderness, other than the general "anathema" of a Commission who might easily have individually or collectively fallen into the same error themselves?

The fact is that theory and formula cannot do everything in bridge construction, any more than it can do everything required and carry us successfully through the world in which we live; and it is doubtful whether a little less theory and a little more commonsense would not have pulled our unfortunate designer through, without this trouble.

Our own designers of the Forth Bridge surely had no full size tests of the huge circular compression members of that structure; and it is not probable that that shape of cross section was evolved from any such formula or tests.

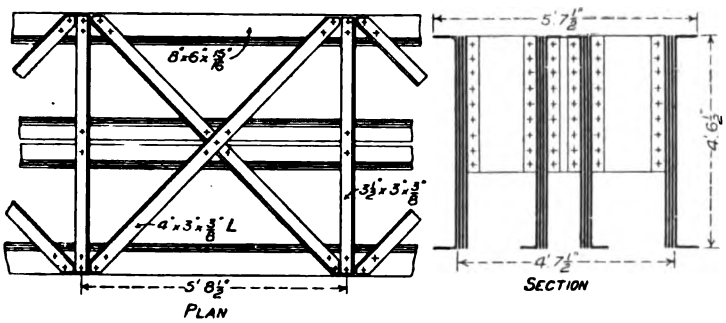


Fig. 2.

The mouse that gnawed the knot and allowed the lion to get loose in this case was, as in the fable, a very little thing, and was merely the lattice arrangement on the top and bottom of the vertical plates of the failed compression member. We regret the thought, but cannot help thinking that a mere inspection of the working drawing of the strut would have enabled any ordinary experienced draughtsman to see where the weakness lay, particularly if he had realised what an enormous compressive load the strut would have to carry.

Then, together with the very insufficient stiffening on the top and bottom of the member, we have the unsuitability of the design of the cross section of the strut itself to consider,

a cross section consisting only of thin plates perhaps correctly designed for tension, but most unsatisfactory for compression stresses.

Here again it is not quite clear why Mr. Szlapka is altogether to blame. Surely, the form of the cross section would have to be approved by the consulting engineer, even if the latter gentleman had not the opportunity to calculate its exact strength. Of course, in English bridges we have the cellular construction for compression booms as at the Britannia and many other bridges, but in these cases there are complete and perfect boxes, and the arrangement of boxes is one that it would be very difficult to destroy by crippling. There are both vertical and horizontal plates connected together by angle irons at the points of intersection, and although this may not be so economical of metal for compressive purposes as is the circular shape, yet the method is one that claims our admiration, for our engineers of more than half a century ago, who were of course working in a totally new and untried material.

In the Quebec Bridge however we have not this complete box or series of boxes, we have the whole resisting strength against crippling depending upon a few angle iron bars and a few rivets, an arrangement which surely might have been expected to fail disastrously.

As regards the stresses per square inch allowed in the unfortunate member, the impression given is that no such unit stresses would for a moment have been allowed in any English structure that were arranged for in this case, even were the design of the strut one that would allow of a great stress.

We are informed that the metal was intended to be stressed possibly from 24,000 lbs. (10·71 tons) to 26,000 lbs. (11·60 tons) per square inch, and that the failed member at the time of the collapse was actually stressed to 18,000 lbs. (8·03 tons) per square inch.

This points to a minimum of weight of metal being thought desirable on account of financial reasons, but on this head the evidence is somewhat contradictory. The report of the Commission states definitely and categorically that they do not believe that any cheap, light or insufficient work was done purposely either by Mr. Cooper or the Phœnix Bridge Company, but one of the American technical journals states that it was a matter of common knowledge that the Quebec Bridge and Railway Company was not strongly financed and that solely in consequence of this lack of funds the project was delayed for some years. The same journal suggests that there must have been a tendency in these circumstances to put up a bridge of conspicuous lightness.

There is one point however that calls for remark, and that is the alarming error made with regard to the dead load. This we understand was taken at too low a figure in the preliminary computation, and notwithstanding this the span was increased from 1,600ft. to 1,800ft. without any revision of the loads.

The Commission state that they cannot find any lack of professional care, skill, or knowledge, in any of the parties responsible for the design and construction of the bridge, and yet the necessity of revising the weights taken in the first computation, even when the span was increased, was apparently overlooked by the engineers of both the Phœnix Bridge Co. and also of the Quebec Bridge and Railway Co. We are informed that the actual dead load of the structure when completed would have been no less than 29 per cent. greater than that assumed in the first case, and that the bridge would certainly have been overstressed at completion. The whole thing is inexplicable in view of the statement that every man responsible engaged in the work quite realised the immensity of the undertaking, that it was to make a record of long span bridge building, and that the pre-eminence of American bridge engineers was at stake.

It is also claimed that there was loose and inexperienced supervision of the work on the site, and that a more responsible resident engineer to take charge of the erection should have been engaged. That this was the case appears to be confirmed by the fact that although the buckling of the failed strut was noticed, yet there was no one on the ground in a sufficiently responsible position to stop the operations and call the workmen away from the bridge, without first asking the consent of the consulting engineer, who, at the time, was a great distance away, in fact, in New York.

It is all very well to declaim about defective supervision, and to say that the loss of life might have been prevented by an exercise of better judgment, but this is loose talk unless the responsible man on the ground felt himself competent to take such an initiative. Any resident engineer on an English railway would not have hesitated for a moment in such a contingency.

We are told that the extreme lightness and apparent weakness of the angle bar latticing of the lower chord members was seen by the President and other officials of the Phœnix Bridge Co., the very point that caused the collapse, whilst the work was being put together in their shops, and that in fact it was found impossible to handle these sigments without bending or damaging the light lattice bars.

This so troubled these officials that they called the attention of the consulting engineer at once to the members and requested him to look further into the question, and at least to go to the works and examine them himself. This inspection, however, never occurred, the consulting engineer did not even go to look at them, and states in his evidence that he had so much confidence in the work of Mr. Szlapka that he had no doubt at all of the efficiency of the design, and accordingly accepted them as sufficient.

Not only this, but when the chord segment was observed to be buckling when erected in the bridge, and a representative was sent purposely to New York in order that Mr. Cooper might be personally consulted on the matter, it was with some difficulty that the consulting engineer was induced to send the famous telegram to call the men off the bridge, a telegram that only arrived at its destination after the bridge lay in the bed of the river.

It is after this difficult to understand how the Commissioners could find that the chief engineer of the Phœnix Bridge Co. had not the technical knowledge to properly organise or direct a work of this magnitude; that the officials of the Phœnix Bridge Co. erred in judgment, and generally were not able to appreciate the difficulties and magnitude of the undertaking.

It is, however, quite plain, that given the responsibility of the Phœnix Bridge Co., they should, as the report states,

have appointed an engineer of erection of long experience in large bridges, to watch the work on site, and given him the powers that such resident engineers usually have, that of making an important decision on the spot, when urgent necessity arrives.

There is no doubt, as one American journal says, that the appointment of so renowned a bridge constructor as Mr. Theodore Cooper raised "a false feeling of security;" but it was hardly complimentary to his brother engineers for that gentleman to say that "There is nobody competent to criticise us."

It is very fortunate, on behalf of the whole engineering profession throughout the world, that the exact point of failure of this immense structure has been so definitely discovered.

The old controversy of pin joints or riveted joints has to some extent been brought up again in connection with this disaster, and one American writer suggests that although the bottom chord segments were joined by means of pins, yet the splices at the joints were of such a nature that statically indeterminate stresses were set up, and that secondary stresses may have had something to do with the failure.

This sort of argument, however, rests on a basis of pure theory only, since practice has not shown that riveted connections are in any way dangerous. Can anyone point out a case where such a design employing riveted connections has failed because of such riveting? In any case no one, whether American or British, will deny that a degree of stiffness is gained by riveting that is lacking in the pin jointed structure.

It may very well be asked whether in any pin jointed structure the pins do actually rotate in the way that they are assumed to do, and if not, whether the connection is not after all one that sets up secondary stresses in just the same way as the riveted joint is presumed to do.

To sum up, an enormous bridge of this magnitude presents many points that are uncertain as regards their exact action under stress. There is very great danger in cutting things too fine and it is unwise to attempt the work without ample funds. Our own Forth Bridge had its own uncertainties and the engineers perhaps did the right thing to employ a large factor of safety in such parts where uncertainties were known to exist, and to make the "co-efficient of uncertainty" very large. No further proof is required that the tubular system of compression members is far and away superior to the method of thin plates lightly connected by trivial latticing. Further it may be said that the riveted joint system holds the advantage over the pin jointed structure, even though there may be secondary stresses. The Forth Bridge surely acts as a whole instead of a series of parts more or less independent secured by pins. Stability is ensured in the latter by its width of 120ft. as compared with the width of the Quebec Bridge, which is only 67ft. The case prones beyond a doubt that science must be used in its proper manner only and that the governing principle must after all be common sense and ordinary prudence.

Figure 1 allows the comparison between the Forth Bridge and the Quebec Bridge to be seen, showing that the latter is not so very enormous after all, although claimed to be the "biggest on the globe."

Locomotive Journals and Bearings.—V.*

London, Brighton and South Coast Railway.

THE engines of this line are not required to make long non-stop runs, but many of the trains are heavy, the line is crowded, and stiff gradients have to be surmounted. There has always been a desire to have the Brighton expresses accelerated so that the journey between London and Brighton in either direction might be done inside the hour, but the engines in use before Mr. D. Earle Marsh, M.Inst.C.E., was appointed locomotive and carriage engineer did not seem able to do the work, at any rate they did not.

Mr. Marsh, to whom we are indebted for the drawings of the details illustrated, introduced more powerful engines of the 4-4-2 or "Atlantic" type, having cylinders 18½in. by 26in., coupled wheels 6ft. 7½in. diam., and a boiler pressure of 200 lbs. per sq. in., but the details illustrated do not belong to engines of that class.

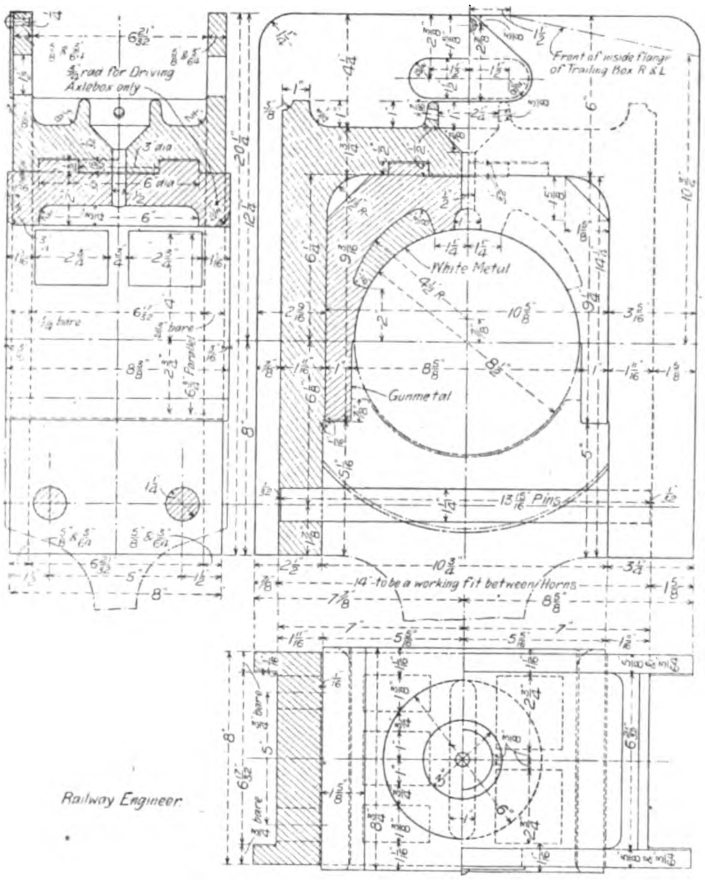


Fig. 20.—Driving Axle Box; London, Brighton and South Coast Railway.

Driving Axle-Box (fig. 20).—In this axle-box there are several points of detail which distinguish it from all others, though it is similar to the L. and North Western and Great Western designs, in that the box is made of cast steel. It is 14in. wide; 8in. deep over the centre, but in addition the top flanges are 4¼in. deep, and the wearing surfaces for the horn blocks 6 17/32in. by 16⅝in. The top corners have fillets 1½in. radius. It carries a dead load of about 7 tons. The bearing is for a journal 8½in. diam. and is 8⅜in. long. The top of the bearing is flat and it is prevented from moving in the box by an annular projection 15/32in. high and 3in. and 6in. diam., fitting into a similar recess in the box ½in. deep so that the box does not seat on the bearing over this area 6in.

*Previous articles of this series appeared in February, March, May and June, 1908.

diam. The corners of the bearing are taken off to 1$\frac{3}{8}$in. square so that the seat is quite clear of the corner fillets of the box. The bearing is made of gunmetal and the journal seat extends to the centre line, has four insets of white metal about 3$\frac{1}{4}$in. by 2$\frac{3}{4}$in., and the sides are prolonged 3in. below the centre, as shown on the drawings.

The top of the box has an oil cup 2$\frac{1}{4}$in. diam. by 1in. deep cast in it. This tapers quickly into a $\frac{1}{2}$in. oil hole leading to

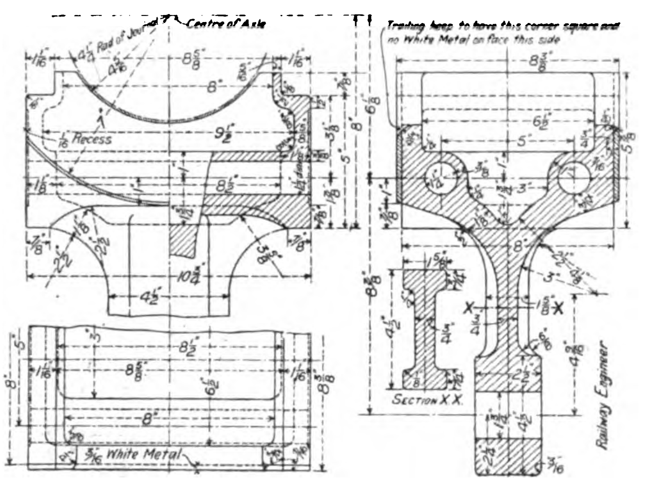


Fig. 21.—Axle Box Keep; London, Brighton and South Coast Railway.

an oil channel 1in. by $\frac{3}{4}$in. by 6in. along the journal bearing. The oil is syphoned by trimmings into the oil cup from the oil well formed by the top of the casting. Inspection holes are provided in the deep top flanges and the outside ones are covered by swinging shutters of $\frac{1}{8}$in. steel plate, as shown.

and made of No. 20 I.W.G. steel wire like the Great Northern pad.

Connecting Rod (fig. 23).—This rod is designed for large numbers of engines with inside cylinders 19in. diam. by 26in. stroke, driving wheels 6ft. 9in. diam., and working pressure of 180 lbs. per sq. in. It is of the bolted or marine type, and in this respect resembles the Caledonian connecting rod

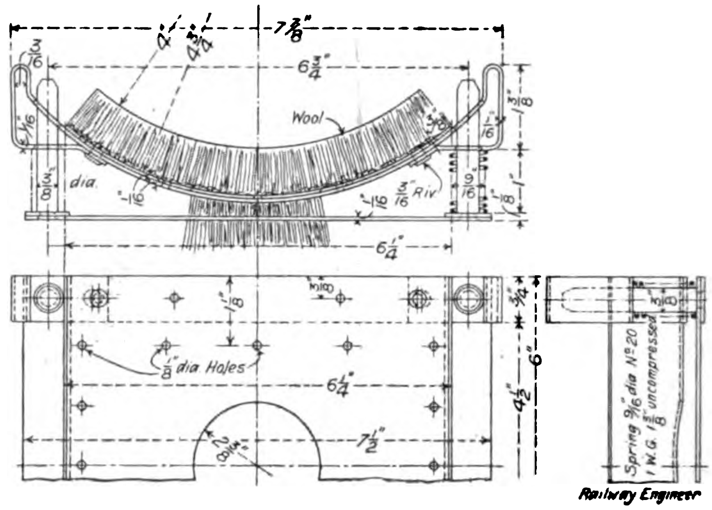


Fig. 22.—Lubricating Pad; London, Brighton and South Coast Railway.

illustrated on p. 65 of our February, '08, issue, but the details, particularly in the big-end, are, it will be seen by comparing the drawings, different. The length of the rod is 6ft. 6in. between the centres. It is made of toughened steel, turned circular in section tapering from 3$\frac{3}{4}$in. to 2$\frac{15}{16}$in. diam.

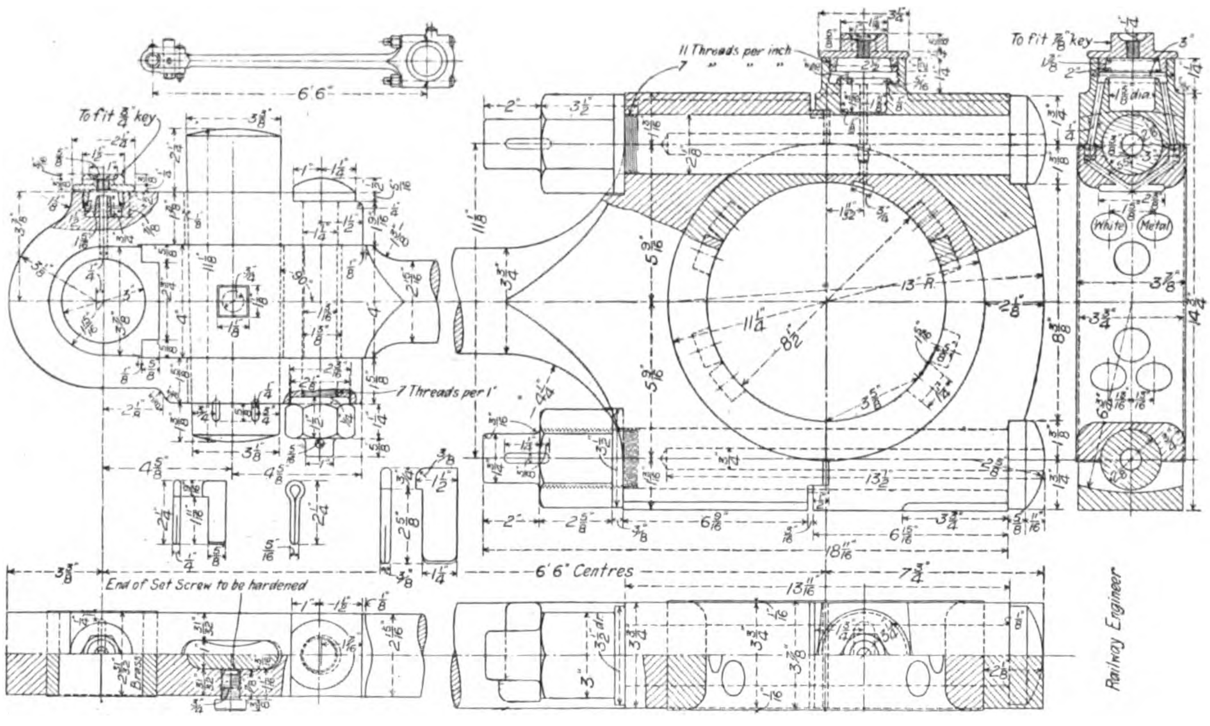


Fig. 23.—Connecting Rod; London, Brighton and South Coast Railway.

The keep (fig. 21) is of cast steel and is cast in one with the spring link. It is attached to the axle-box by two wrought-iron pins 1$\frac{1}{4}$in. diam., as shown, and has its sides faced with white metal. The top of this casting carries the lubricating pad (fig. 22), which is supported at its four corners by vertical spiral springs $\frac{9}{16}$in. diam. by 1$\frac{5}{8}$in. uncompressed

The fork for the big-end bush does not extend beyond the centre, the toughened steel strap or keep, which has a middle section of 2$\frac{1}{8}$in. by 3$\frac{3}{4}$in., being brought round and fitted into its ends as shown.

The big-end bush is made of gun-metal in halves. The bearing is 8$\frac{1}{2}$in. diam. by 3$\frac{7}{8}$in. long and is fitted with 4

groups of white metal insets each $1\frac{1}{4}$in. diam. by $\frac{5}{8}$in. thick, arranged as shown. The bolts and nuts are of steel, $2\frac{1}{8}$in. diam., with a $\frac{3}{4}$in. hole drilled from the head nearly to the commencement of the screw thread. This practice somewhat lightens the head of the rod and secures a uniform section in

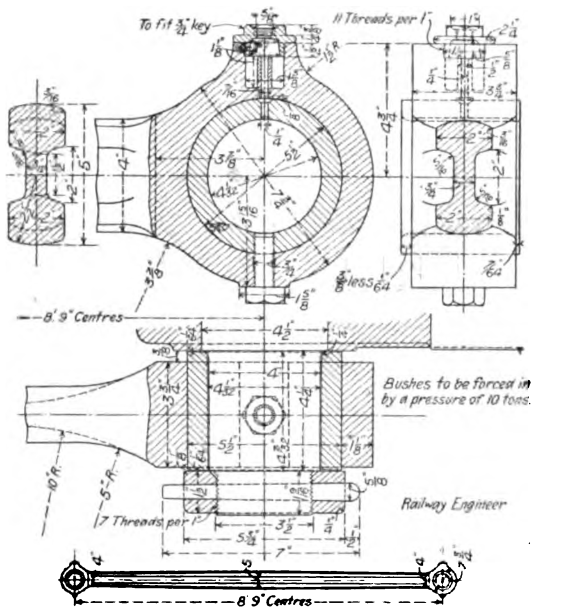


Fig. 24.—Coupling Rod; London, Brighton and South Coast Railway.

the bolts. The heads are provided with flats which are let into the keep to prevent their turning. The nuts are 3in. deep and are secured by $\frac{3}{8}$ by $1\frac{1}{4}$ split cotters through the bolt-ends.

The oil cup is on the strap and is cut out of the solid and is provided with a brass cap which has a filling hole tapped 11 threads to the inch and which is closed with a cork or wooden plug. The oil is syphoned by trimmings down $\frac{1}{4}$in. feed holes on either side of the top bolt, see drawing, into an oil channel $\frac{3}{4}$in. by $2\frac{3}{8}$in. by $\frac{1}{8}$in. deep.

The small butt end is 4in. by $2\frac{13}{16}$in. and the gun-metal bush (in halves) is attached to it by a strap of toughened steel $1\frac{1}{16}$in. thick at the middle of the bend. The ends of the strap are retained by a $1\frac{1}{4}$in. steel bolt reduced to $1\frac{3}{16}$in. diam., where it passes (clear) through the butt and provided with a flat on its end and a nut having a recessed seat and secured by a $\frac{5}{16}$in. split pin. The shear is taken and the adjustment of the bearing provided for by a steel cotter 1in. by $3\frac{3}{16}$in. (round ends) middle section, secured by a $\frac{3}{4}$in. steel set-screw and two $\frac{3}{8}$in. by $\frac{1}{4}$in. split cotters.

The small-end bearing is 3in. diam. by $2\frac{31}{32}$in. long.

The oil cup is cut out of the solid and provided with a brass cap similar to that on the big-end.

Coupling Rod (fig. 24).—This rod is 8ft. 9in. long between the centres. It is of steel machined to the usual I section. It is 5in. deep in the middle and 4in. at the ends. The heads are 2in. and the web $\frac{3}{4}$in. thick. The top and bottom corners are rounded off to a $\frac{3}{16}$in. radius and the minor ones to $\frac{1}{8}$in. radius, the fillets to the web being $\frac{5}{16}$in. radius. The heads are turned on the top and bottom.

The eyes are $7\frac{3}{4}$in. diam. by $3\frac{3}{4}$in. and carry plain phosphor bronze bushes nearly $\frac{3}{8}$in. thick, the bearings being $4\frac{1}{32}$in. diam. by $4\frac{7}{32}$in. for journals $4\frac{1}{4}$in. long. The bushes are secured by $\frac{3}{8}$in. set screws in the usual manner.

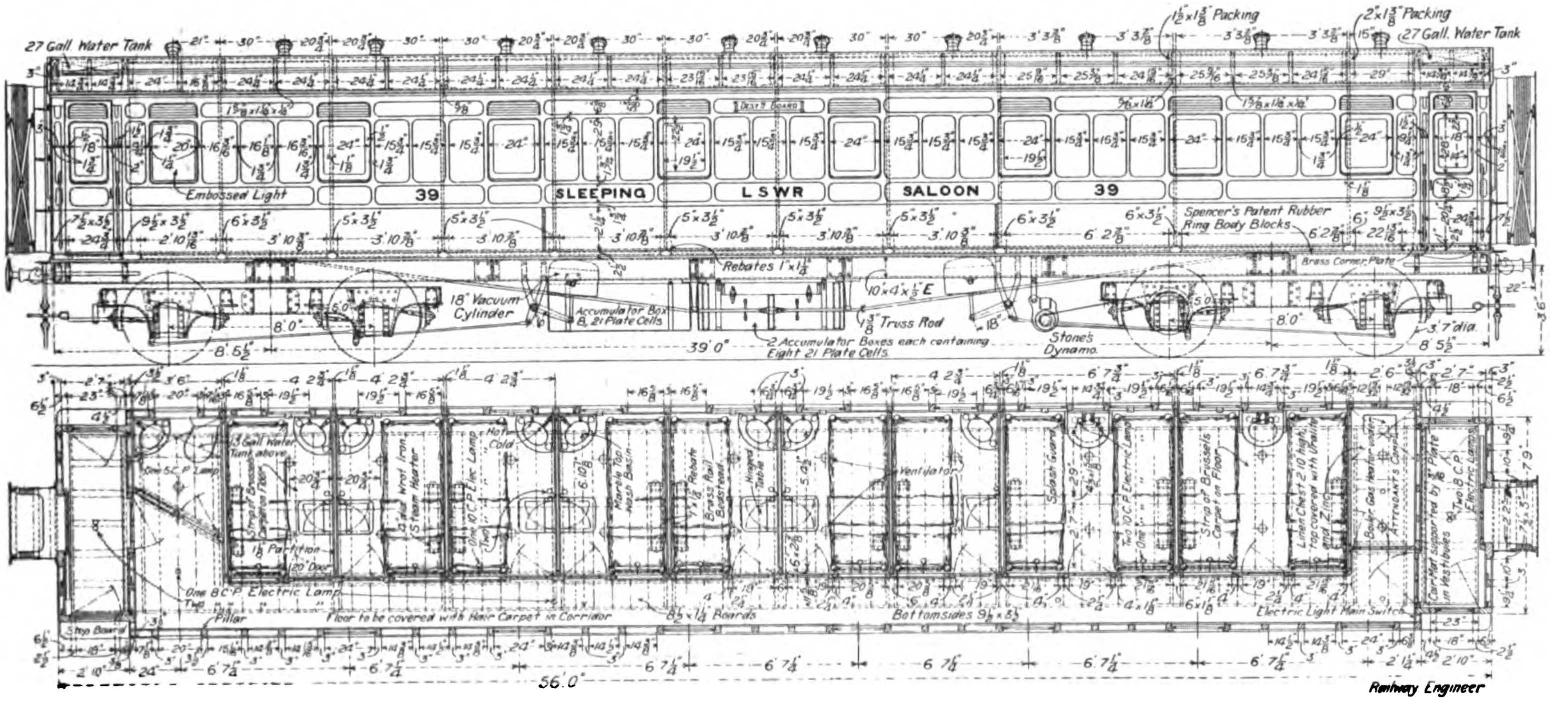
The oil cups are cut out of the solid and finished like those on the connecting rod.

The rods are retained on their pins by screwed washers with a taper pin split at its small-end.

Sleeping Saloons; London and South Western Railway.

In our last issue we gave a description, together with a view of the interior of one of the compartments of the Sleeping Saloons which have lately been built at the L. and South-Western R. carriage works at Eastleigh, to the designs of Mr. S. Warner, carriage and wagon superintendent, and, as promised, we are now able to publish drawings of these handsomely furnished vehicles.

It will be seen from the notes on the drawings that these



Sleeping Saloon; London and South Western Railway.

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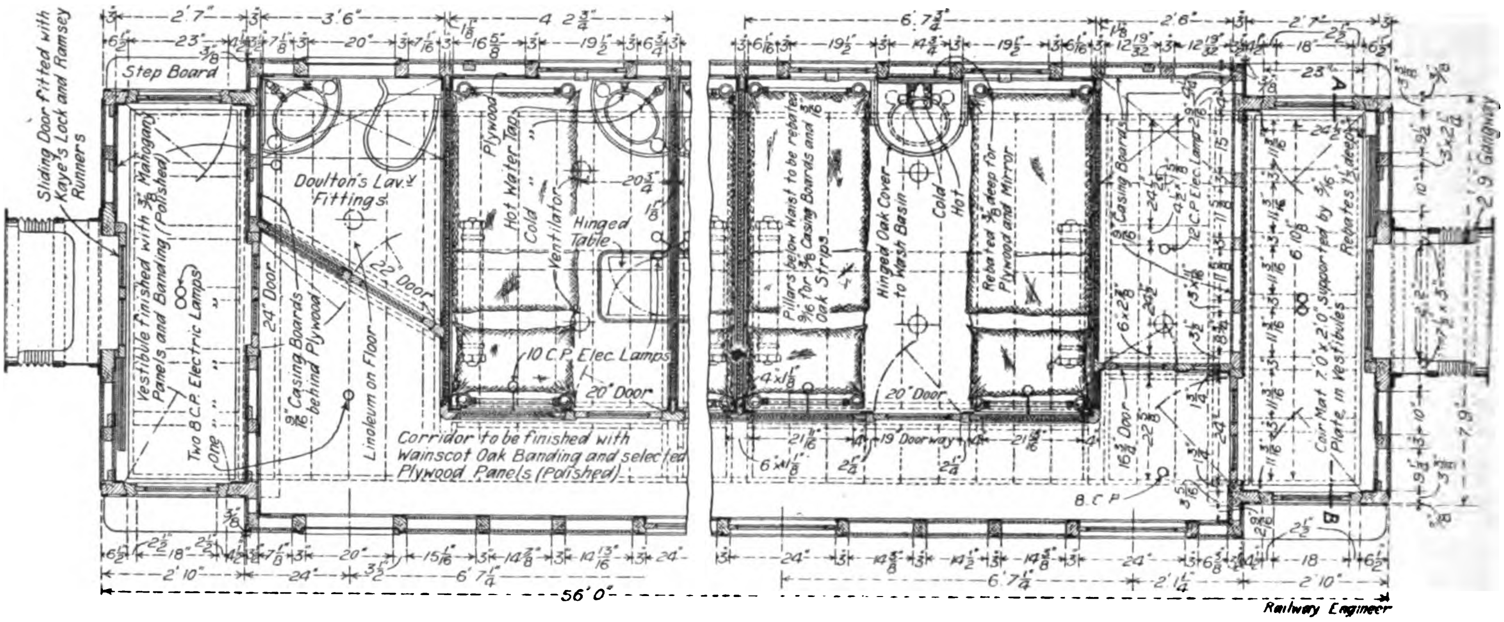
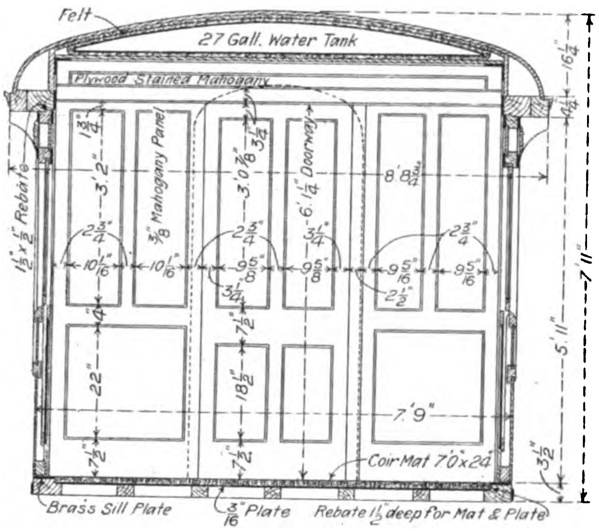
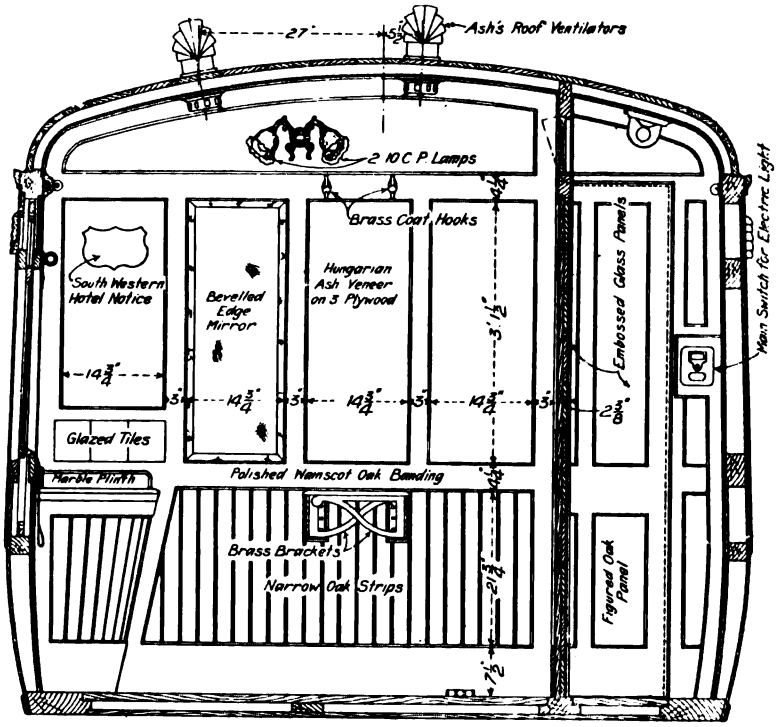




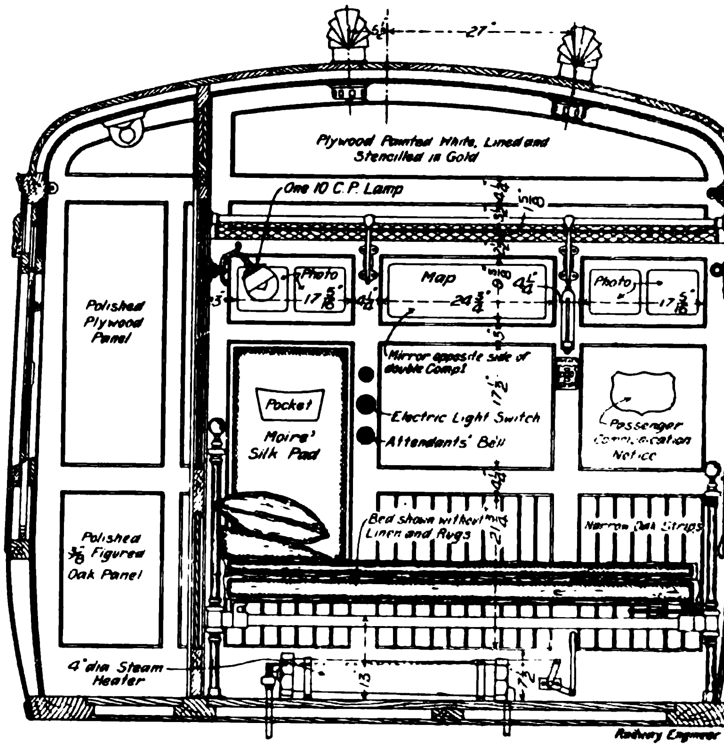
Section A B.

Sleeping Saloons are fitted up with the latest and most approved style, and that they are replete with every appliance calculated to render a night journey comfortable and pleasant.

The saloons are divided into seven single and two double berth compartments, furnished with brass bedsteads, lavatories, folding tables, towel racks, mirrors, etc. As the bedsteads are not fixtures they are readily removed so that the compartments may be easily and thoroughly cleaned. The sides of the compartments are lined with polished wainscot oak facias and Hungarian ash panels, and the roofs of ply wood, painted white ornamented with gold; all mouldings and heavy upholstery likely to harbour dust have been carefully avoided as far as possible. The Saloons are provided with electric light (generated by Stone and Co.'s system), the switches being arranged so that passengers, without leaving the beds, may regulate the light so as to have



Wash Basin side of Single Compartment.



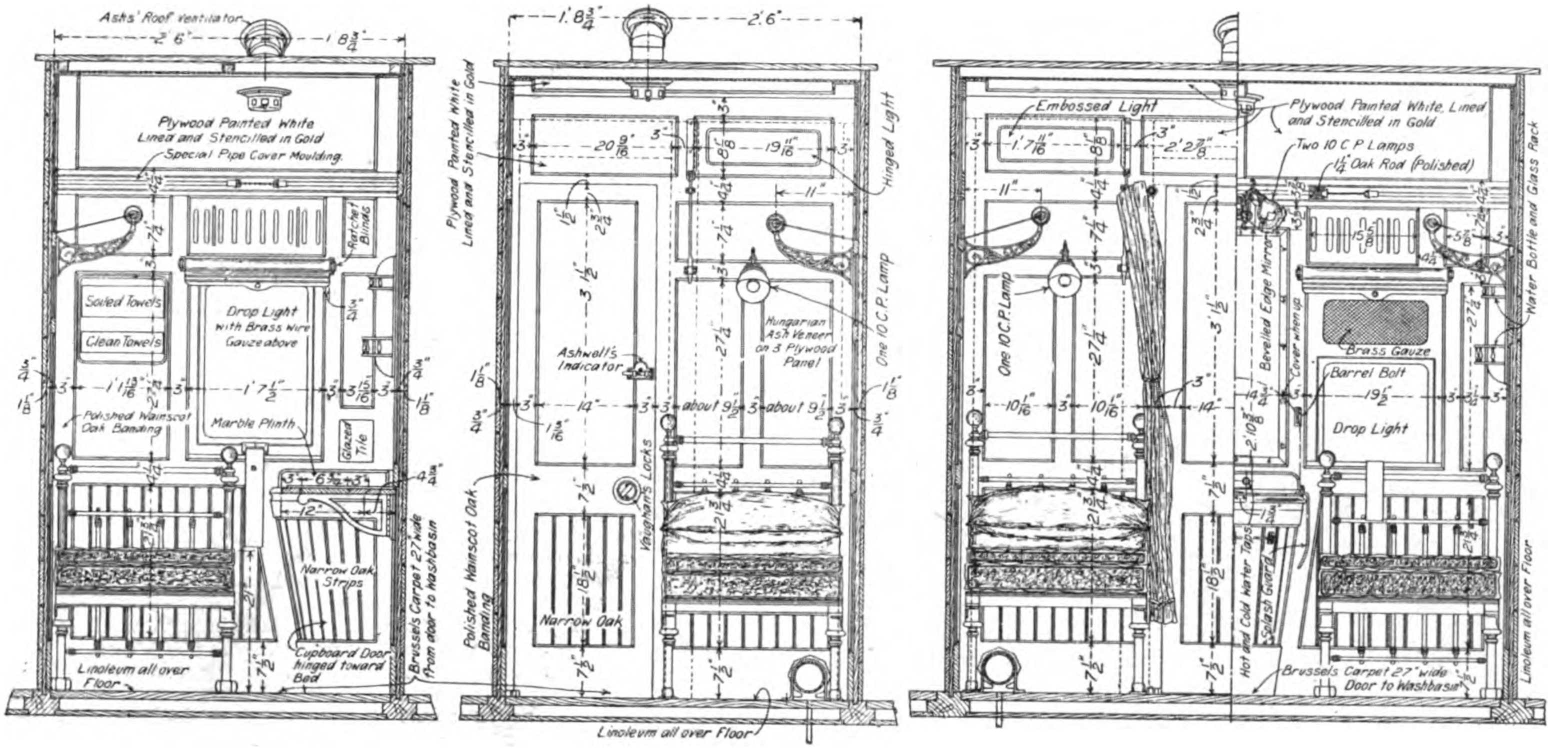
Bed side of Single and Double Compartments.

Sleeping Saloon; London and South Western Railway.

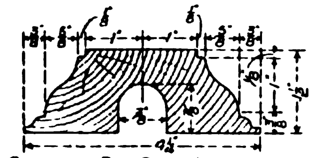
a full or "glow" light as they wish, and a reading lamp is fitted over the bed. The wash basins are supplied with hot and cold water, and the compartments have steam heaters also directly under the control of the passengers.

are inserted. The bolster springs are of Timmis' differential sections, and the side bearing springs are 5ft. centres having 8 plates, 4in. by ½in.

The bogies are built up of pressed steel plates; the wheel

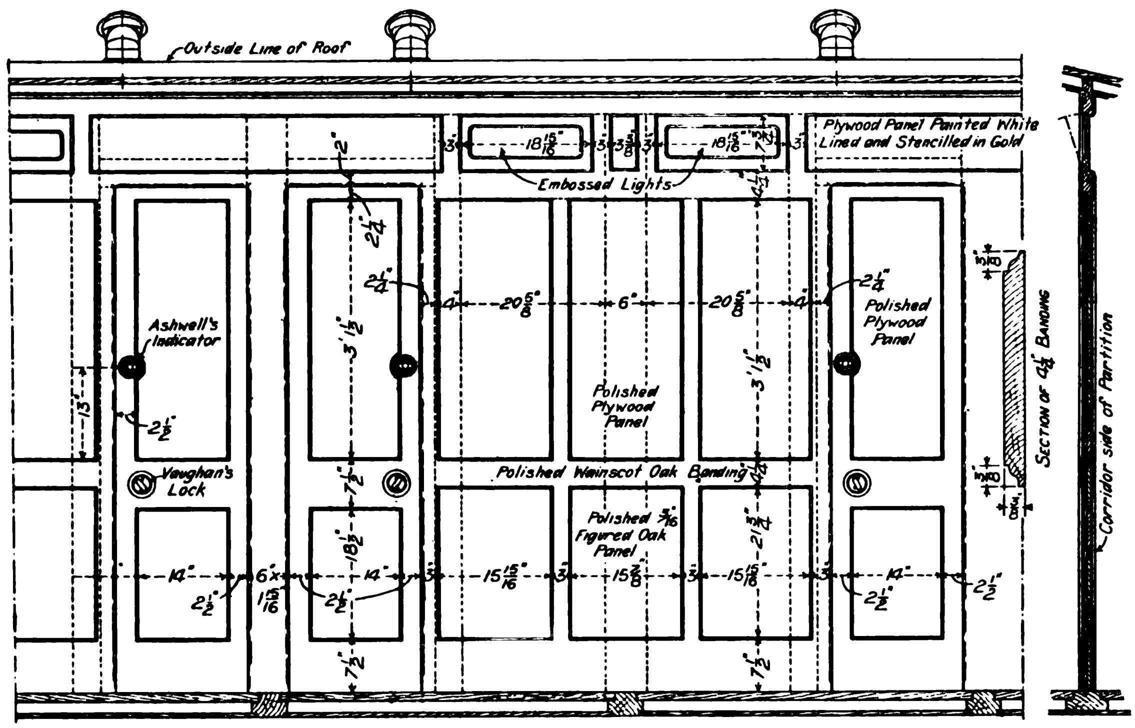


Coach side of Single Compartment. **Corridor Partition side of Single Compartment.** **Corridor Partition side of Double Compartment.** **Coach side of Double Compartment.**



SECTION OF PIPE COVER MOULDING

The lavatory fittings are highly finished, and were supplied by Doulton and Co. The tops of the basins are of St. Anne's marble, and the basins are of white ware, decorated with gold. Tiles are fixed round and above the basins, so that all splash marks are easily cleaned off. In the double berth compartments the lid of the wash-basin forms, when closed, a convenient table, and when up, by an ingenious arrangement, shields the beds and mirrors from splashes.



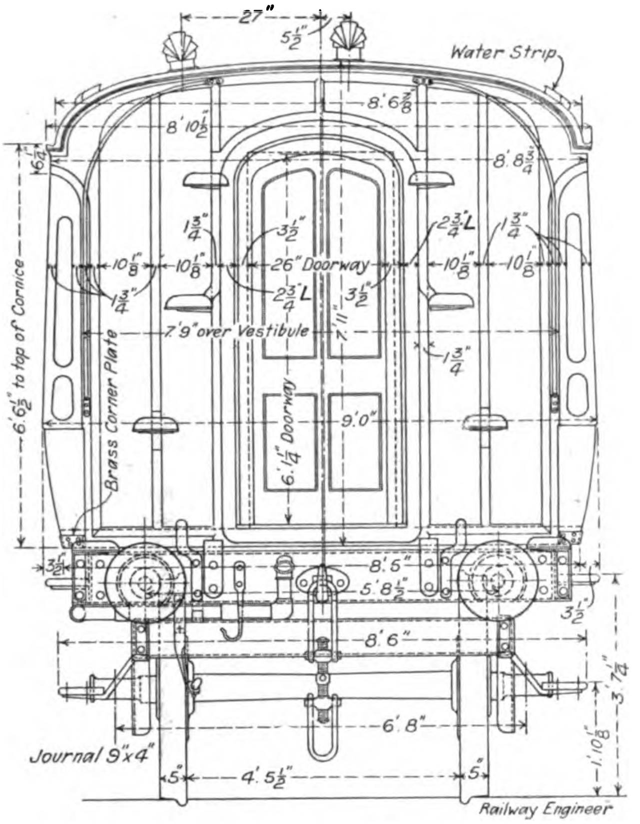
Outside Corridor Partition of Single Compartment.
Sleeping Saloon; London and South Western Railway.

Each compartment has Ash's ventilators in the roof.

Particular care has been paid to make the riding as quiet as possible. The floors are double, and between the body and the under-frame Spencer's patent rubber ring body blocks

base is 8ft., and the length between the centres 39ft. The wheels are 3ft. 7in. on the tread.

Externally the saloons match the rest of the L. and South Western stock. The ends of the waist panels are covered with a brass strip 1¼in. wide, let in flush, and well bedded



End View, Sleeping Saloon ; London and South Western Railway.

with white lead, there being three lengths to the body.

All the wheels have double brake blocks, each underframe having two of the Vacuum Brake Co.'s 18in. cylinders.

Electric Traction Installation on the Heysham, Morecambe and Lancaster Section of the Midland Railway.

The equipment of the Heysham, Morecambe and Lancaster section of the Midland R. was completed in May though the length between Morecambe and Heysham has been opened to traffic (by electric trains) since 13th April. The installation is one of particular interest, as it is the first in this country on the single-phase alternating current system.

The overhead construction was designed and carried out under the direction of Mr. W. B. Worthington, engineer-in-chief, Mr. J. Sayers, telegraph engineer, and Mr. Argyle, northern divisional engineer, of the Midland R. It is similar as regards the type of suspension to that adopted on the Hamburg-Altona R., the patents for which in England are held by Siemens Bros., of Westminster, the chief difference between them being the suspension of the catenary wire, which is the design of Mr. Sayers.

The installation comprises the double line between Heysham and Morecambe; Morecambe and Lancaster (Green Ayre); and the single line from Lancaster (Green Ayre) to Lancaster (Castle); the total length as single road being about 21 miles. The line, fig. 1, passes under a number of overbridges, mostly of the arched shape and the clearance of these bridges has been a matter of considerable interest.

The use of a single bow for travelling in both directions necessitates the bow being symmetrical about the centre of the coach and this brings the bow necessarily very close to the structure of the bridge. In order to get through at all it is necessary to take the contact wire well out towards the centre of the arch so that it may come down low, but yet will be clear of the loading gauge so that the other side of the bow may clear the structure properly.

In addition to the bridges, the Lune Viaduct presented a special problem, as it is on a nine chain curve and terminates at the end of Lancaster Station, which is also on a curve.

The contact wire is of the figure 8 section and is run in lengths of from 800 to 1,000 yards. One end of each length is fixed through insulators to a terminal gantry and the other end is attached through suitable pullies, etc., to a weight equal to about 1,200 lbs. The fixed end is always that at which the train enters, the tendency of the bow is therefore always to straighten the contact wire, which is 70 sq. m/m section. At first the strain put on was equal to 800 lbs., and the horizontal stagger was made equal to 4ft.; that is, 2ft. from the centre line of the coach, but the experimental trials which went on for some months before passenger trains were run showed that the total friction of pull-offs, etc., was such as to make it necessary to increase the tension to about 1,200 lbs. for a length of 1,000 yards. With this weight the strain goes fairly evenly throughout the whole length. It was also found that a 4ft. stagger for a bow, which measured from tip to tip 7ft. 1in., was too much for running at high speeds. The line is situated in a country swept by very violent gales, and it is now considered that a stagger of 2ft. is a more practicable figure, though part of the line is actually run with 3ft. stagger. (Fig. 1a.)

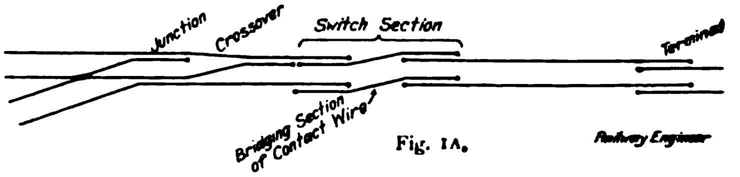


Fig. 1A.

The height of the contact wire from rail level varies from 18ft. 3in. in the open to 13ft. 3in. under bridges. It is suspended by short loops about 4in. long from a steel cable called the auxiliary wire. The loops are fixed to the contact wire, but are movable on the auxiliary wire. The auxiliary wire again is held by the main catenary cables, of which there are two; the main catenary span being thus broken up into six short spans on the auxiliary.

The two catenary cables are clipped together throughout their length, except for about 3ft. on either side of the insulator where they divide, fig. 3, to pass through the grooves of the insulators. The catenary is therefore free to move for this distance, and the strains in spans due to unequal loading are equalised: at the same time it is secure in the case of the breaking of the wire, as has actually been proved by experience.

Section switches of the double break air pattern are fixed on the top of the poles supporting the gantries so as to isolate the up and down line, or to isolate the different branches. Each section switch is in addition duplicated and the connection from one contact wire to the section ahead of it is accomplished by means of a short section of switch wire which requires to be connected to the contact wires before the line is switched through, at this point. This arrangement was adopted in order to get a duplicate break, and what is more important a short length of line into which a car can run without bridging by means of its bow two sections which it was supposed might require to be isolated. The switches are provided with padlocks. A similar type of switch is in use at the various stations to enable the station staff to earth the overhead wiring in case of emergency.

The gantries are connected together by a separate overhead steel cable, which is earthed every half mile, the same earth plates being used for lightning arresters of the horn type, the object being to diminish the number of earth plates requiring attention, and thus to give better security from danger due to the poles being charged by a leaky insulator. This earthed steel cable has been erected in every case between the contact wire and the telegraph wires which are open on one side of the line, and it is believed that its presence has had a great effect in reducing the electrostatic induction from the contact wire to the telegraph wires. The object was to avoid, if possible, cabling telegraph and telephone wires, and so far the results are favourable to the idea that it will not be necessary to put all such open wires underground when high pressure traction systems are erected overhead. At the same time it will certainly be necessary to provide some sort of high resistance leak on any wire parallel to such a system, as in certain circumstances, if the wire were, for instance, thrown out of work by disconnection at the test board, there might be an electrostatic potential between it and earth with a very high voltage which would be very inconvenient for maintenance purposes.

Straight creosoted wooden poles have been mostly used, but at Morecambe Station and at one or two other points, fig. 2, it has been necessary to erect lattice steel poles and lattice girder gantries owing to the big spans.

Where wooden poles are used the gantries are made of two angles brought together at the ends, but kept apart for the greater part of their length by distance pieces 1in. thick, enabling the bolts from the insulator saddles to drop in the gap, so

giving a great range of adjustment of the insulator position without any necessity for drilling. (Figs. 2 to 8).

Before settling the dimensions of the insulators, fig. 3, advantage was, by the kindness of Messrs. Siemens Bros., taken of the experiments made by that firm to ascertain what was the minimum distance at which a 6,600 volts 25 cycle circuit would maintain an arc in the heaviest weather from an insulator shed. The steel bolts supporting the insulators are encased with ebonite with a view to getting practically double insulation with one insulator. In addition to this, the insulator itself is made very massive and in two pieces, as the line is very likely to suffer from damage from stone throwing at the large number of level crossings, and in addition will be exposed to the worst of weathers. The insulators in combination with the twin catenary cable brings the side strain of the overhead gear below the level of the inside bolt, and there is no point at which the catenary cable itself is being deformed by the pressure of any clamp, and no point at which the mechanical waves tend to break the wire at a point of reflection.

The outer rail on each line is bonded throughout its length with Forest City bonds in duplicate under the fish-plates. At all the crossings and junctions all rails are bonded together for greater continuity with the wheels of the coaches; these bonds and those used for cross bonding are ordinary copper cable bonds. Very great care was exercised in bonding the line to prevent any moisture getting into the drilled holes or on to the bond plugs during the process, and in very wet weather the work was abandoned. By means of protective devices it was found possible to go on with bonding in moderately wet or damp weather, but the tests carried out when the whole of the work was finished or the resistance of each bond showed in an interesting manner that although the bonds were absolutely first class, those which were carried out in perfectly dry and fine weather were quite distinguishable, by resistance test, from those which were carried out in damp or misty weather. It will be interesting to note, as time goes on, whether this difference in resistance is intensified.

The rails are earthed at Heysham Harbour in the sea by duplicate copper earth plates. At Morecambe they are earthed at the end of the Midland R. pier; these plates being also of copper, but for protection they are dropped into a large cast iron caisson recovered from an old Midland bridge. At Lancaster the rails are earthed to the cast iron columns of the bridge where they rest in the bed of the river, where water is always flowing.

Recording ammeters were put in these various earths, with a view of indicating the proportion of current which returns by these routes.

There are no feeders other than the two contact wires.

The overhead wire works at a potential of 6,600 volts, single-phase-alternating current, 25 cycles, generated at the existing power station at Heysham, in which the necessary additional machinery has been laid down to enable it to supply single-phase current, it being a direct current station.

The motive power of this station is gas. There are two "Mond" producers of 750 to 1,000 h.p. capacity each, with the accessory blowing, steam producing, cooling and cleaning apparatus.

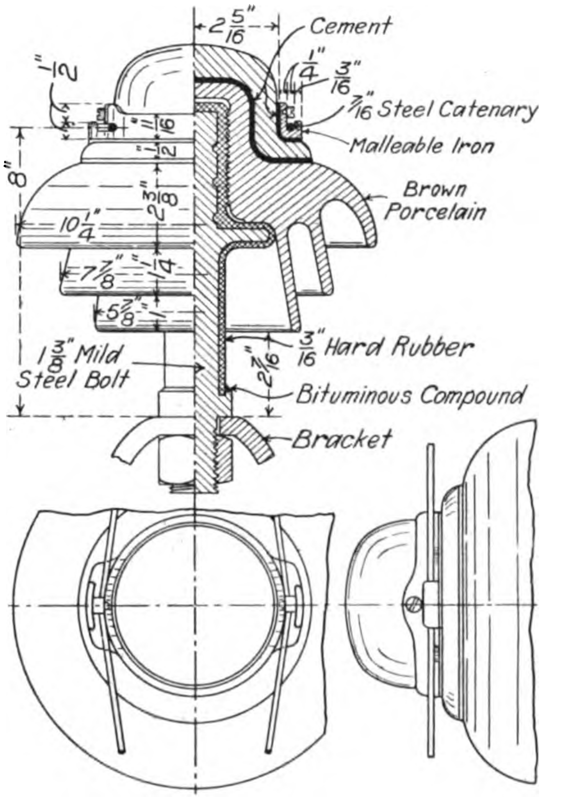


Fig 3.—High Tension Insulator.

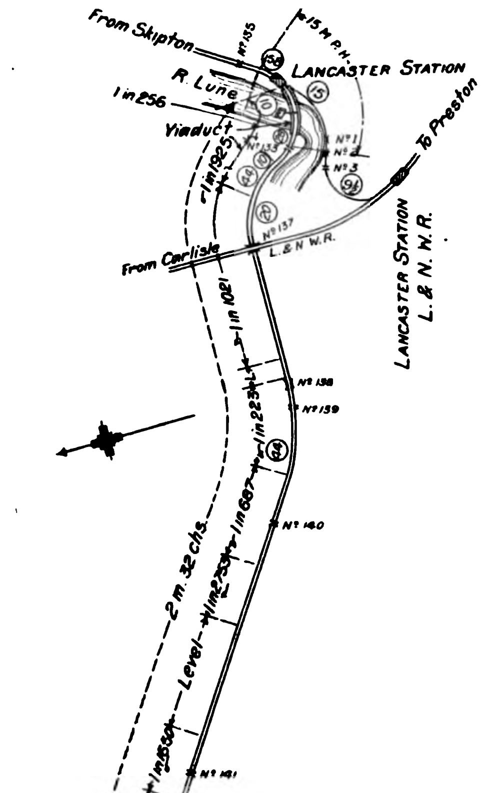
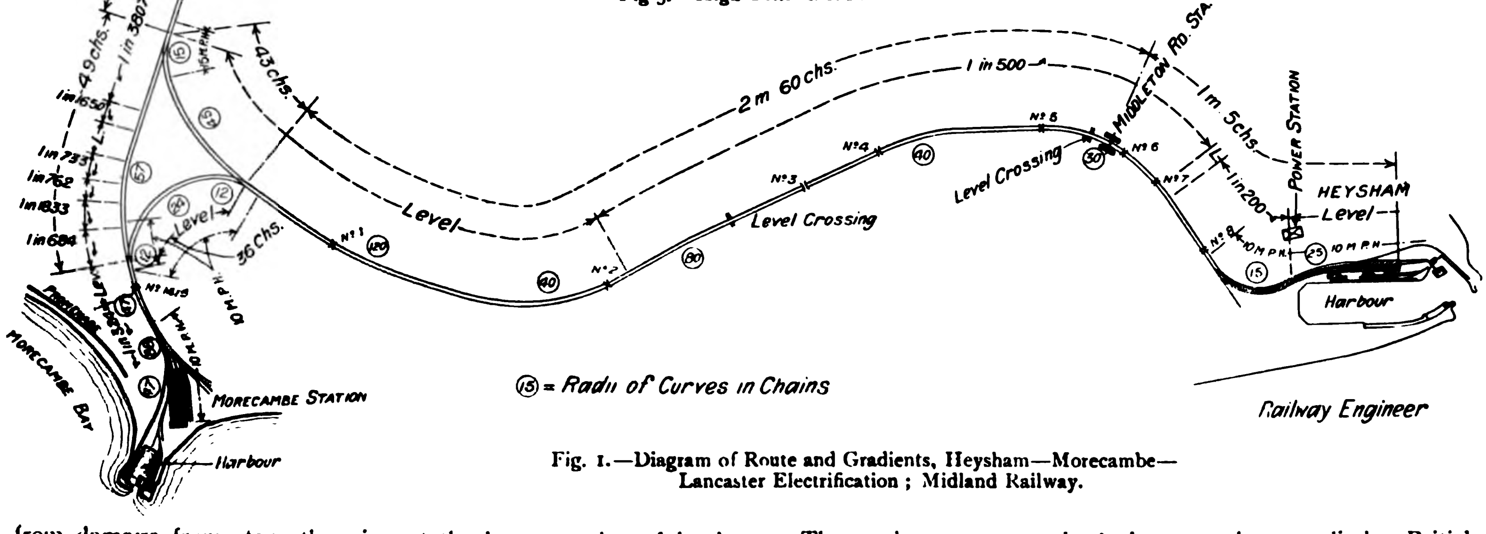
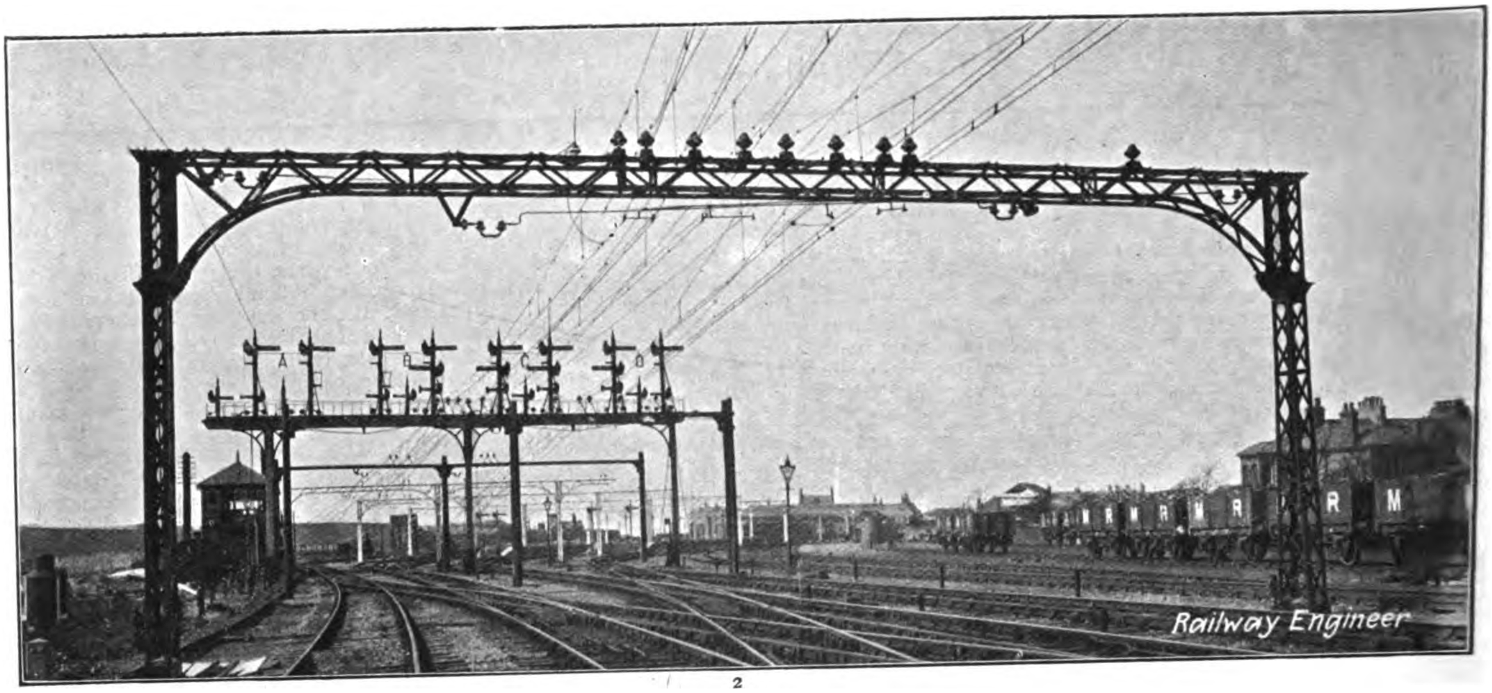



Fig. 1.—Diagram of Route and Gradients, Heysham—Morecambe—Lancaster Electrification; Midland Railway.

The engine room contained three 250 h.p. 3-cylinder British Westinghouse Co.'s engines, driving 150 K.W. (direct-current, 400 volts) generators, and a battery having a capacity of 100 K.W. for 5 hours, with the usual corresponding rates for shorter and longer periods. The existing load on the station, consisting chiefly of fast speed, heavy motored cranes, is very variable and the battery has been used, in conjunction with a British Westinghouse Co.'s automatic reversible booster, for taking up the "peak" loads.

In connection with the traction installation, an additional 350 h.p. 235 K.W. Westinghouse Co.'s engine and generator, also generating 460 volts direct-current, has been added. The single-phase current is obtained through two D.C.-A.C. motor-generators, by the Electric Construction Co.



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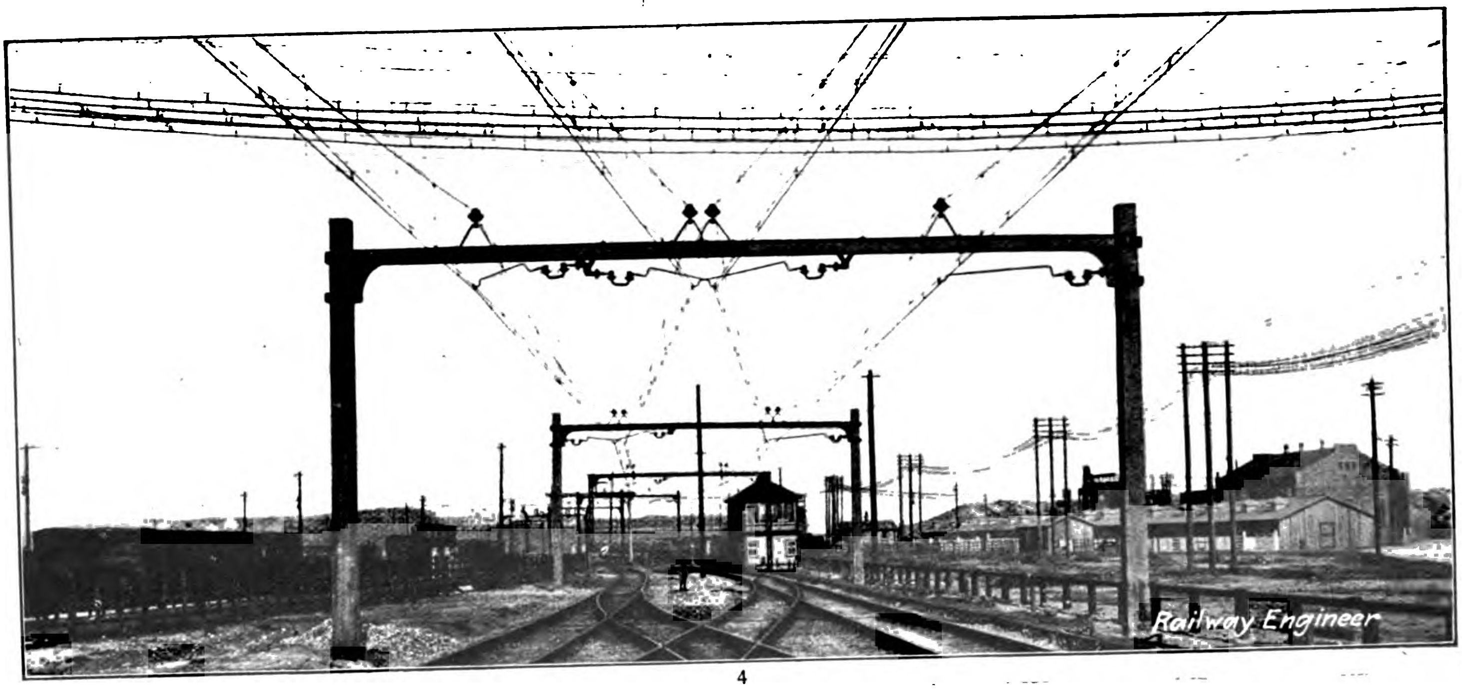

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Overhead Construction, Fig. 2.--Morecambe ; Fig. 4.—Heysham ; Fig. 5.—At Overbridge, Morecambe.

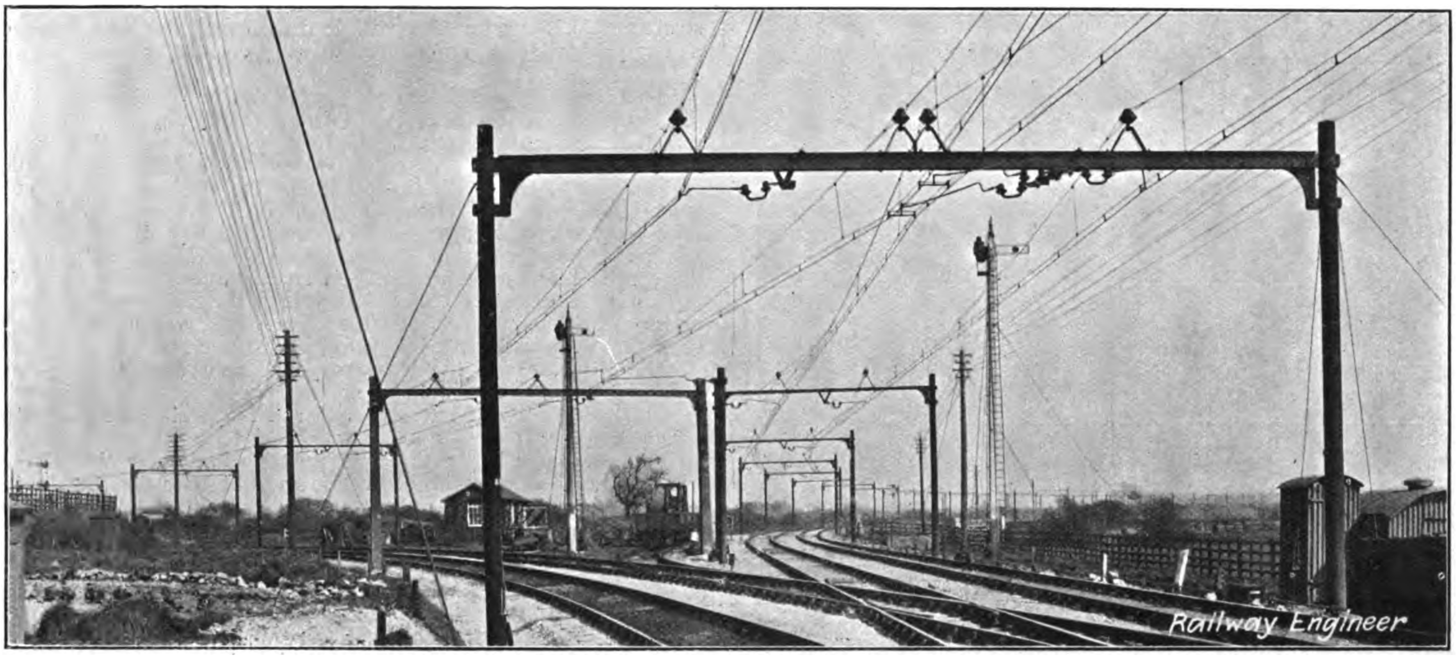


Fig. 6.—Overhead Construction, Torrisholme.

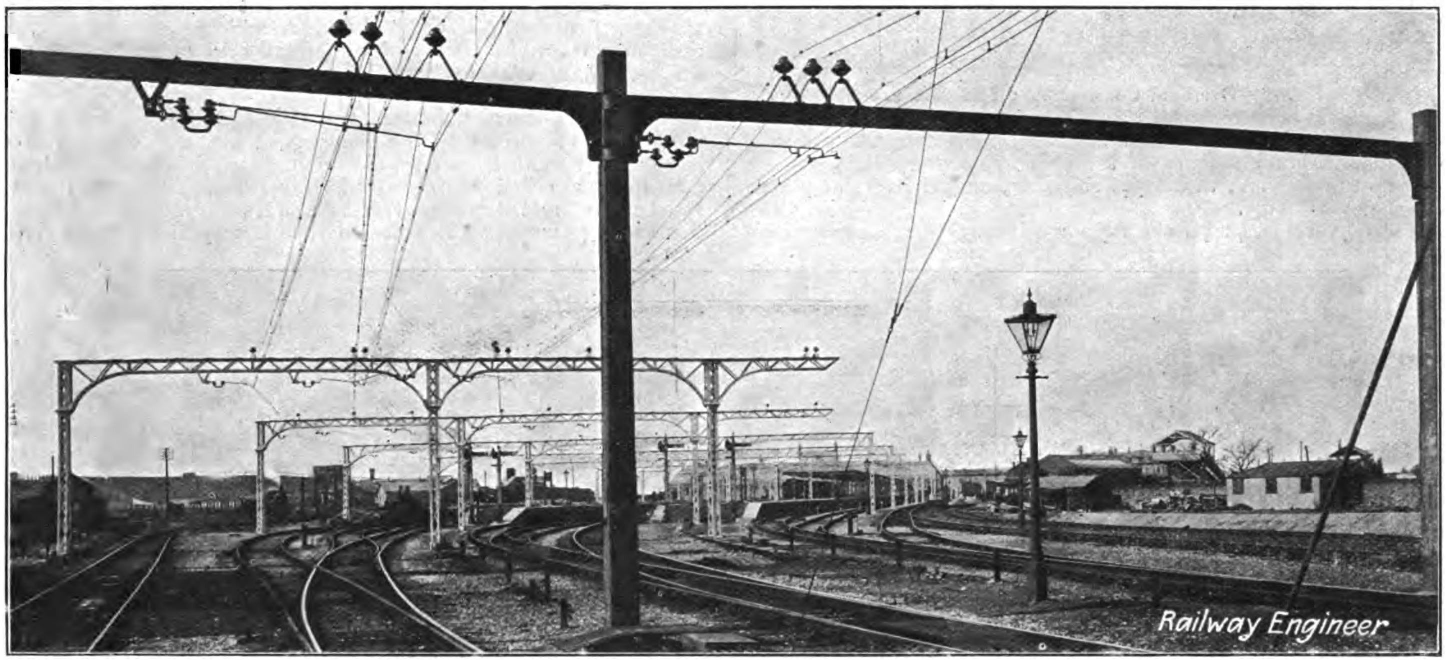


Fig. 7.—Overhead Construction, Morecambe.
Heysham—Morecambe—Lancaster Eletrification ; Midland Railway.

The demand on the station, fig. 9, will show very heavy "peaks," during which periods the intention is, whatever the actual load may be, to work engines to their full overload capacity (20-25% in the old and 10-15% in the new set) before the battery is called upon to discharge heavily. The latter will, however, be called on to work up to its full one hour rate of 750-1,000 amperes. A new battery booster by the Lanashire Dynamo and Motor Co. (whose machine is particularly suited for this method of working) has been installed. As it was found that the generators were working on the falling portion of their characteristics and their pressure dropped badly as their loads increased, exciters of 3 K.W. capacity were mounted on the engine bedplates and belt driven from a pulley fitted on the generator shaft, the compound windings being fitted on these exciters, and varying their voltage, and consequently that on the main generator fields, so that the existing copper on the latter was fully utilised and without any serious stoppage of the generating sets.

The new booster is of the three-wire type. With a comparatively low continuous rating it satisfactorily commutates the "peak" discharges up to 750-1,000 amps.; and it can be set to make the engines work up to their overloads as above, or to work under practically any other conditions, without any serious drop on the bus-bar voltage.

The new generating set comprises the Westinghouse Co.'s latest type of gas engine, having three cranks and sets of cylinders, "forced" lubrication, and a speed of 300 r.p.m. Its performance so far proves it to be an excellent engine, and as reliable as any steam engine.

The motor generators are in many ways exceptional machines which have to work under exceptional conditions. The load varies from nothing to upwards of 1,000 K.W. in very short periods. The specification called for machines to be capable of a continuous output of 150-200 K.W. with a temperature rise of 80° F. of safely carrying output overloads of 900 K.W. instantaneous, 600 K.W. for ½min., 500 K.W. for ¾min., and 300 K.W. for 2½min., and of being tested under a regular cycle of these overloads, with underloads in between, for 8 hours. The internal driving losses were also required to be kept down, while on the alternating current side they were required to regulate within 6% on throwing-off a non-inductive load equal to the full continuous load, and within 20% on throwing-off a similar but inductive

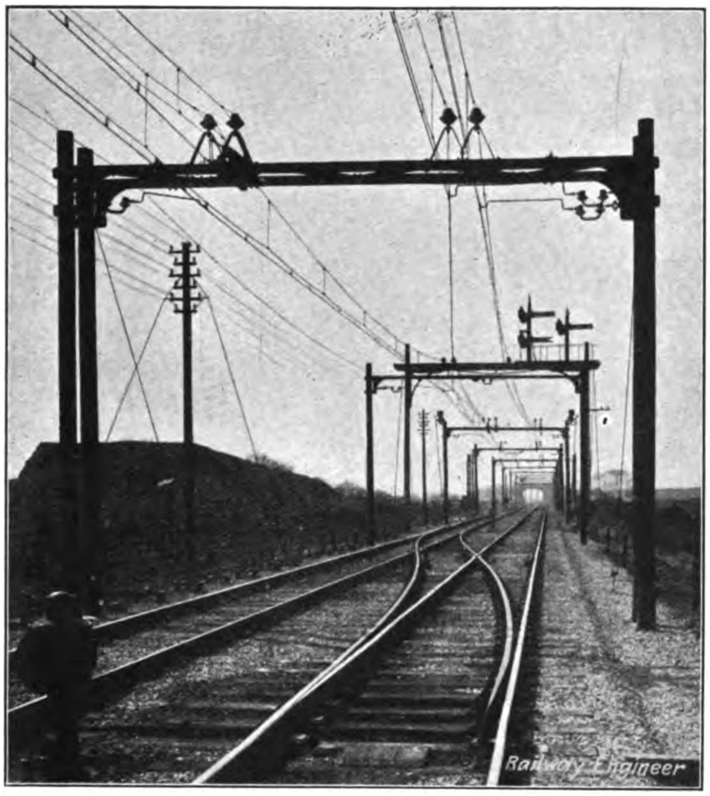


Fig. 8.—Overhead Construction; Torrisholme.

assistance of external means if necessary to restore the pressure to normal within 7 seconds of the coming on or throwing off of loads up to 600 K.W. at 0.8 power factor, or 300 K.W. at power factors down to 0.3.

Widely varying proposals were received. The Electric Construction Co.'s machines were selected as they are very compact and require a small amount of driving current, besides having a high efficiency.

The Makers' specification was 175 K.W. on continuous rating, the machines on test being well within the specified temperature rise, but not excessively so. During the experimental running of the trains each of the sets have several times been subjected to loads up to 900 K.W. input without the slightest commutator trouble and smaller overloads of 600, 500 K.W., etc., have been very frequent, and have been carried with equally satisfactory results. The alternating current regulation is also fully up to the specified requirements, and on an average after the switching on or throwing off of a heavy load the voltage is restored to its normal of 6600 volts within 3 seconds, while the voltage even then only varies about 300 volts each way.

The direct current motor is compound wound with commutating poles, the series winding being a very slight one, and put in principally to assist the two sets to run in parallel satisfactorily, which they do.

The alternator has a three-phase star winding so that if one winding breaks down the other two may be used for the single-phase supply, otherwise no use is made of the three-phase connections. The machine is of the standard internal revolving field type, and it excited from an exciter carried on the end of the bedplate and spur geared up to about 1,100 revolutions. This exciter has laminated fields and is compound wound, its series winding carrying a portion of the main motor current, so that (so far at least as varying loads of equal power factor are concerned) the tendency of the alternator to drop in volts is thus compensated for.

Compensation for varying power factors is effected by means of a regulator, designed and constructed by the Electric Construction Co. and the first of its kind, which inserts or extracts resistance from the circuit of the shunt field of the exciters by the action of solenoids, which are respectively excited as the voltage exceeds, or is less than, the normal.

The direct current motor armature and the revolving field alternator are carried on the same shaft without any intermediate bearing. There are only two main bearings on the machines and these are ball bearings, which, so far, have given every satisfaction, and have proved very advantageous in reducing the starting current, which at 460 volts is only about 75 amperes,

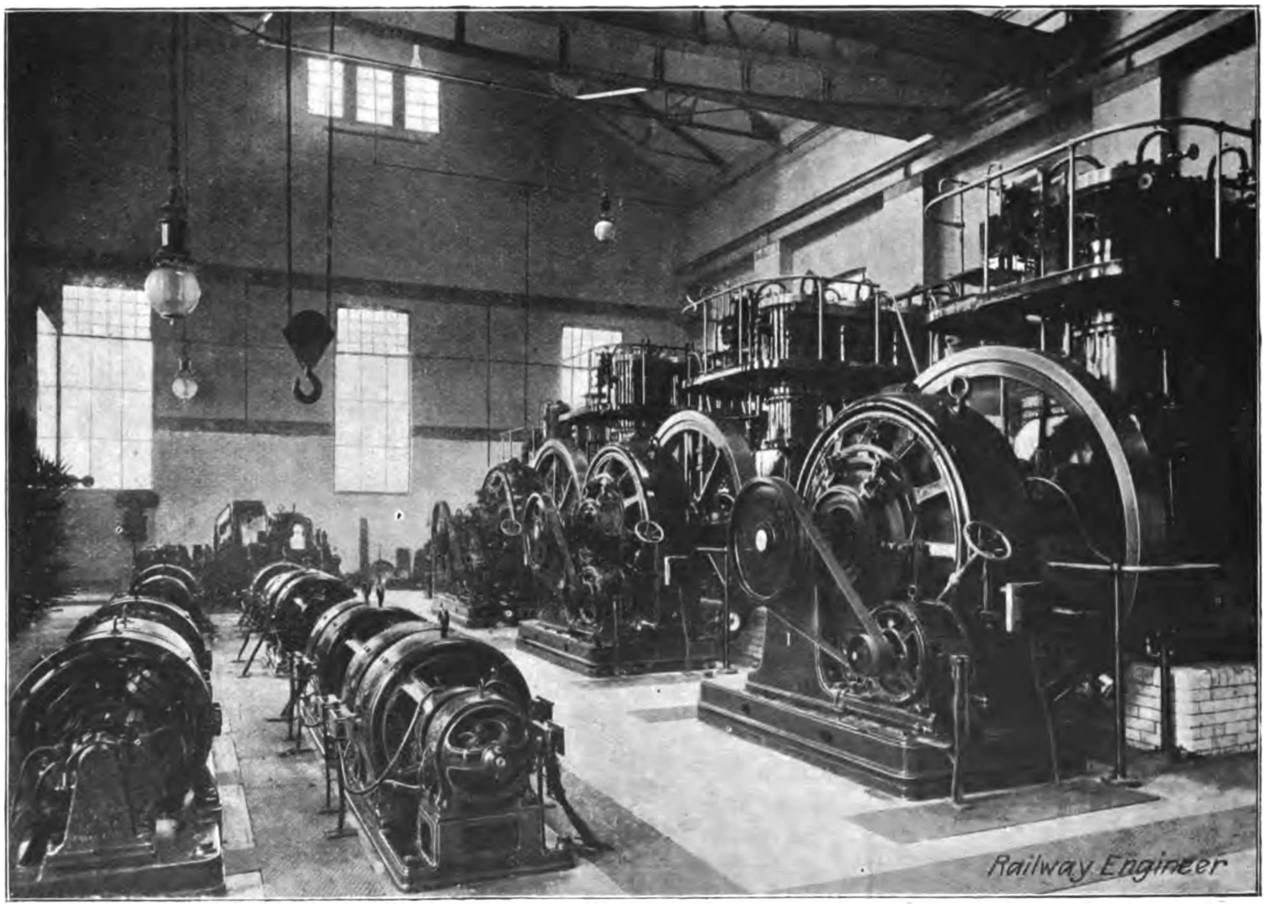


Fig. 9.—General View of Heysham Power Station.

and the no-load loss, which is about 23 K.W., with the exciter and alternator fully excited.

The switchboard was designed and constructed by the railway company, the instruments being made by the Westinghouse Co. From fig. 10 it will be seen that each of the motor generators is supplied from the low tension bus-bars through a no-voltage and overload circuit breaker. The shunt circuit is excited through a separate double pole knife-switch, with kicking contacts and resistances. Starting resistance is cut out by means of a set of knife-switches. By means of a throw-over switch these can be used to start either set of the machines, a heavy triple-bladed knife switch being thrown in finally and connecting them direct to the bus-bars when the machines are fully started up.

On the alternating current side each alternator is connected up to the bus-bars by a hand operated oil switch and the current passes from the bus-bars through duplicate automatic circuit breakers to duplicate feeders passing out to the overhead line. All the circuit breakers, both high and low tension, have time limit devices. The exciter shunt fields of the alternators are also connected through double pole switches with non-inductive contacts and resistances. The instruments used consist of an ameter, on each of the direct current motor circuits, and a voltmeter, ammeter, and watt-hour motor on each of the alternator circuits, all operated through transformers. There is also an indicating watt-meter between the bus-bars and the out-going feeders, and the regulator is connected to the same transformer.

The high tension apparatus is contained in a lock-fast expanded metal chamber placed over at the back of the actual switchboard, the switches being operated from the handles of the latter through rodding. The door of this high tension chamber is interlocked with the holding-up coil of the motor circuit breakers, so that unless the door is closed neither motor generator set can be started while if it be opened during running everything stops.

The rolling stock consists of three trains, there being three motor cars, two with equipments by Siemens Bros., and one equipped by the Westinghouse Co. The order being thus divided was purely that Messrs. Siemens were supplying all-electric control, which was preferred to the Railway Co., whereas the Westinghouse Co. preferred to adhere to their electro-pneumatic control apparatus. In addition to the motor cars four trailer cars have been specially built. Each end of each of the trailers and of the motor cars is equipped with driving apparatus. The services contemplated are every 20 minutes between Heysham and Morecambe, and every 15 minutes between Morecambe and Lancaster, using a single train in each case. The trains will, however, not be worked up to anything like this service throughout the day. (Figs. 11, 12 and 13.)

The rolling stock was built at Derby to the designs of Mr. D. Bain, carriage and wagon superintendent.

The motor cars are open central corridor type, 60ft. long by 9ft. wide, divided into three compartments seating 72 passengers, and vestibule compartment at each end for the driver or guard.

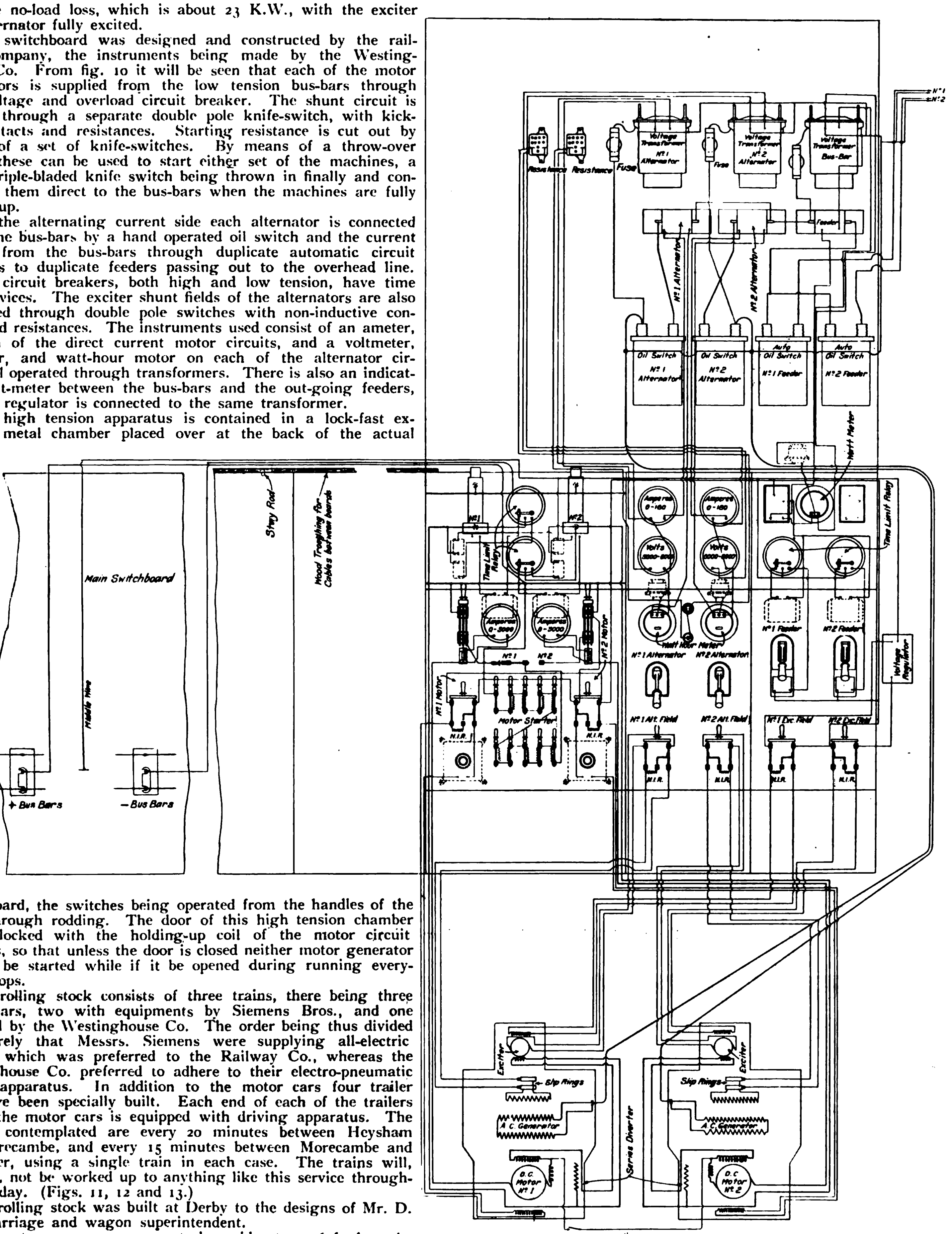


Fig. 10.—Diagram of Connections, Motor Generators and Switchboard; Heysham Generating Station.

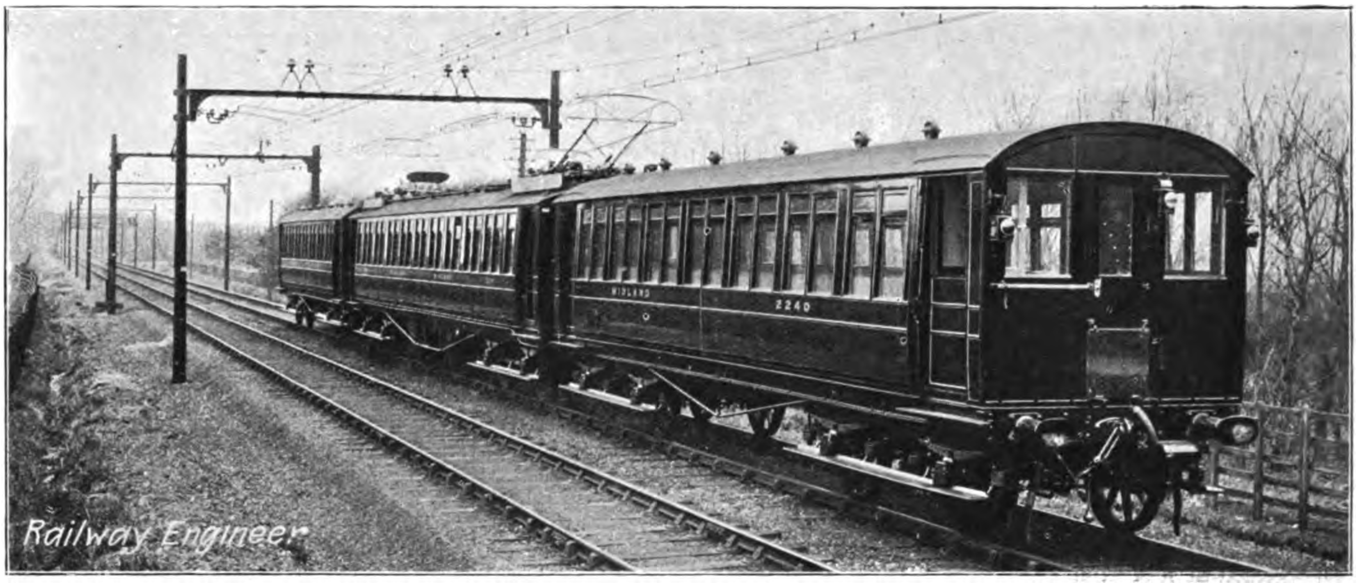


Fig. 11.—Three-Coach Train on Line at a Section.

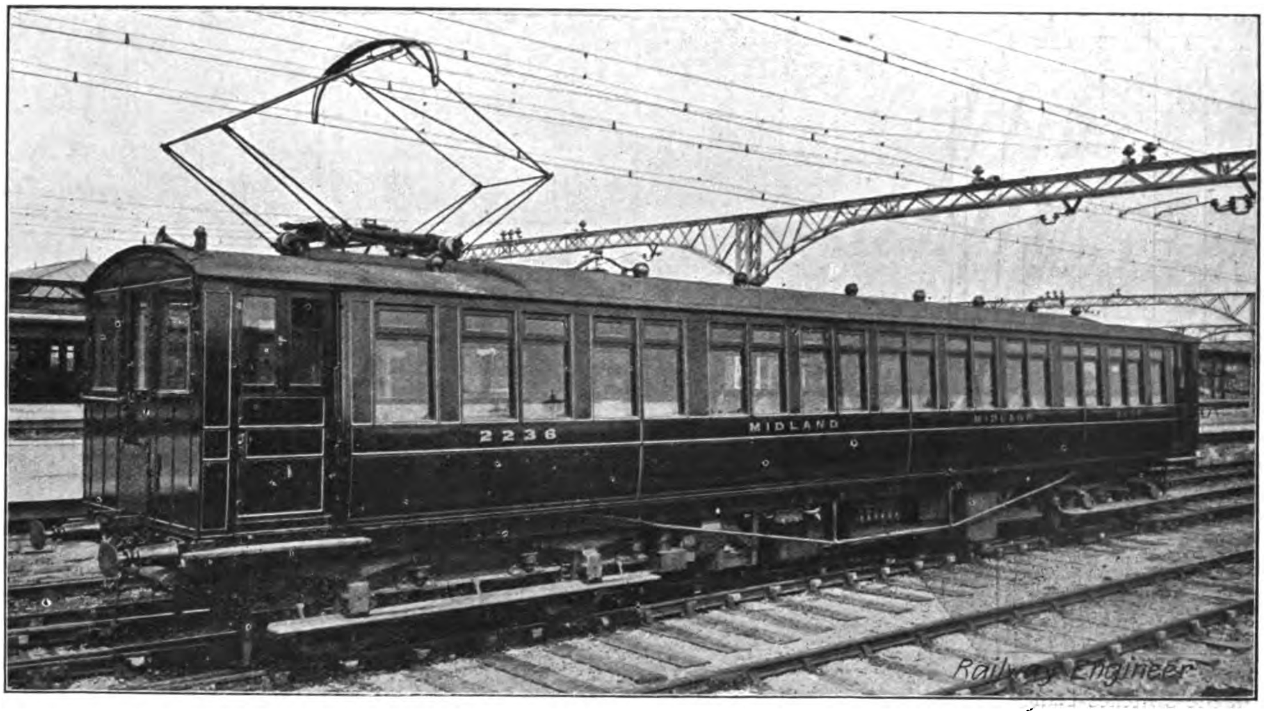


Fig. 12.—Westinghouse Car showing bow, and apparatus suspended on underframe.

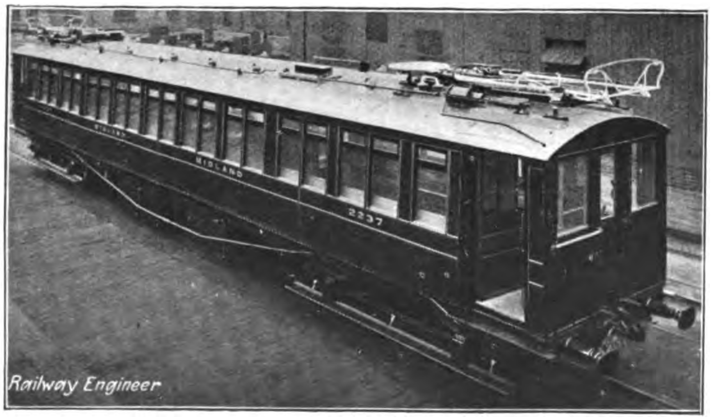


Fig. 13.—Siemens Motor Car showing bows and wire netting on roof.

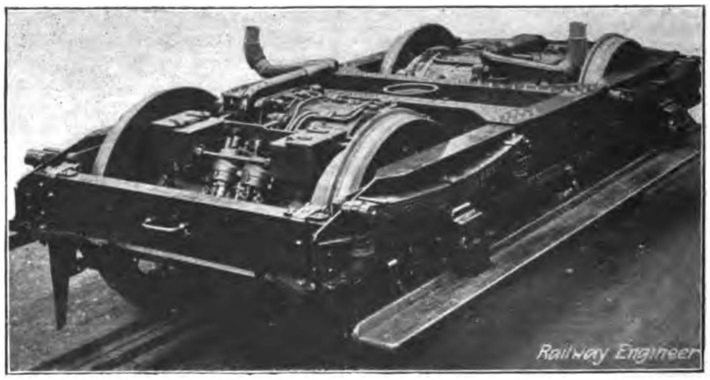


Fig. 14.—Motor Bogie.

The central compartment is 25ft. long with transverse seats, while the other two compartments, each 13ft. 5in. long, have longitudinal seats.

Internally the cars have been finished with a view to facilitate their cleaning: the roof is lined with millboard painted white, the sides, ends, etc., of polished oak, and the seats are covered with perforated sycamore.

The underframe is constructed of Z and channel steel, connected by angle knees and gusset plates, and well supported with truss rods.

The trailing bogies are the Midland R. standard pattern, composed of pressed steel members. The wheel base is 8ft., and the wheels are 3ft. 7½in. diam. on tread.

All the cars are fitted with both hand and power brakes, under easy control of the driver at either end of the vehicle. The power brake is of the vacuum type, the vacuum being obtained by pumps driven from independent motors. Trailing bogie wheels are braked on both sides.

The trailer cars are 43ft. long by 9ft. wide and have a driver's vestibule at either end. The underframing is of light construction.

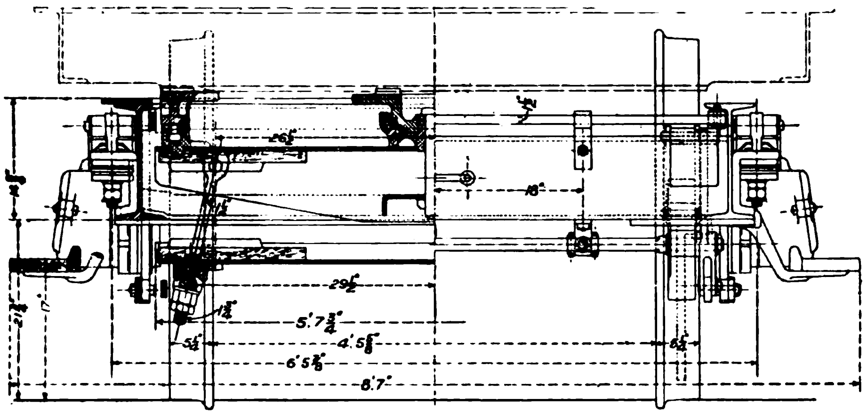
The motor bogies were constructed by the Locomotive Department. The axles are of forged steel, 6¼in. diam., parallel between the wheels; the journals being 9in. by 4¾in. diam. The wheel base is 8ft. 6in. and the driving wheels are 3ft. 7½in. diam. on the tread when new. As only a few cast steel centres were required an existing tender wheel pattern was made use of, and consequently the wheels are considerably heavier than is necessary. The tyres are 5¼in. wide and are shrunk on the centre and held by screws through its rim. Figs. 14 and 15 show the construction. The steel side frames are of rolled joist section, 14 by 6, and the end frame of 10 by 4 channels. The transom, or centre cross frame, is box section, built up of plates and angles. The axleboxes are of a special pattern, but very similar to the M.R.R. standard carriage axleboxes suitably altered to act as driving boxes. (See fig. 16.) The brasses which are white-metalled subtend a slightly larger angle than the usual carriage brass, being about the same angle as locomotive brasses. The horn blocks are cast steel bolted with the usual fitted bolts to the framing. The box is a good sliding fit in the blocks longitudinally, but across, *i.e.*, lengthwise of the axle it only actually fits the blocks a distance of about 1¾in. at a point opposite to the centre of the bearing area, being tapered out the remainder of its length both ways to the extent of about ⅛th of an inch, this obviating any tendency for the axle to be nipped during running at the throat of the journal.

The brakes, as is usual in electric motor bogies, owing to want of room, act only on one side of the wheels. The blocks are hung from brackets on the bogie end frame, and are actuated by levers connected to bars running lengthwise under the inside top flange of the side frames. An arc shaped cross bar connects these bars together and is coupled to the brake pull rod through a shackle and roller arrangement, which allows for the swivelling of the bogie on curves without affecting the brake gear adjustment. The weight of the whole bogie is 6½ tons, but the extra weight due to the use of the wheels above mentioned accounts for about 1 ton of this.

Each motor car has two brake cylinders; the trailer cars have only one.

The vacuum is obtained from a Gresham and Craven vacuum pump supplied by the Vacuum Brake Company. The pump is motor driven with a worm speed reduction running in an oil bath. A single brake pump is used on each motor car.

The control gear for the pumps is arranged so as to give a high and a low speed, the latter being ¼ of the higher. The pump runs at the low speed



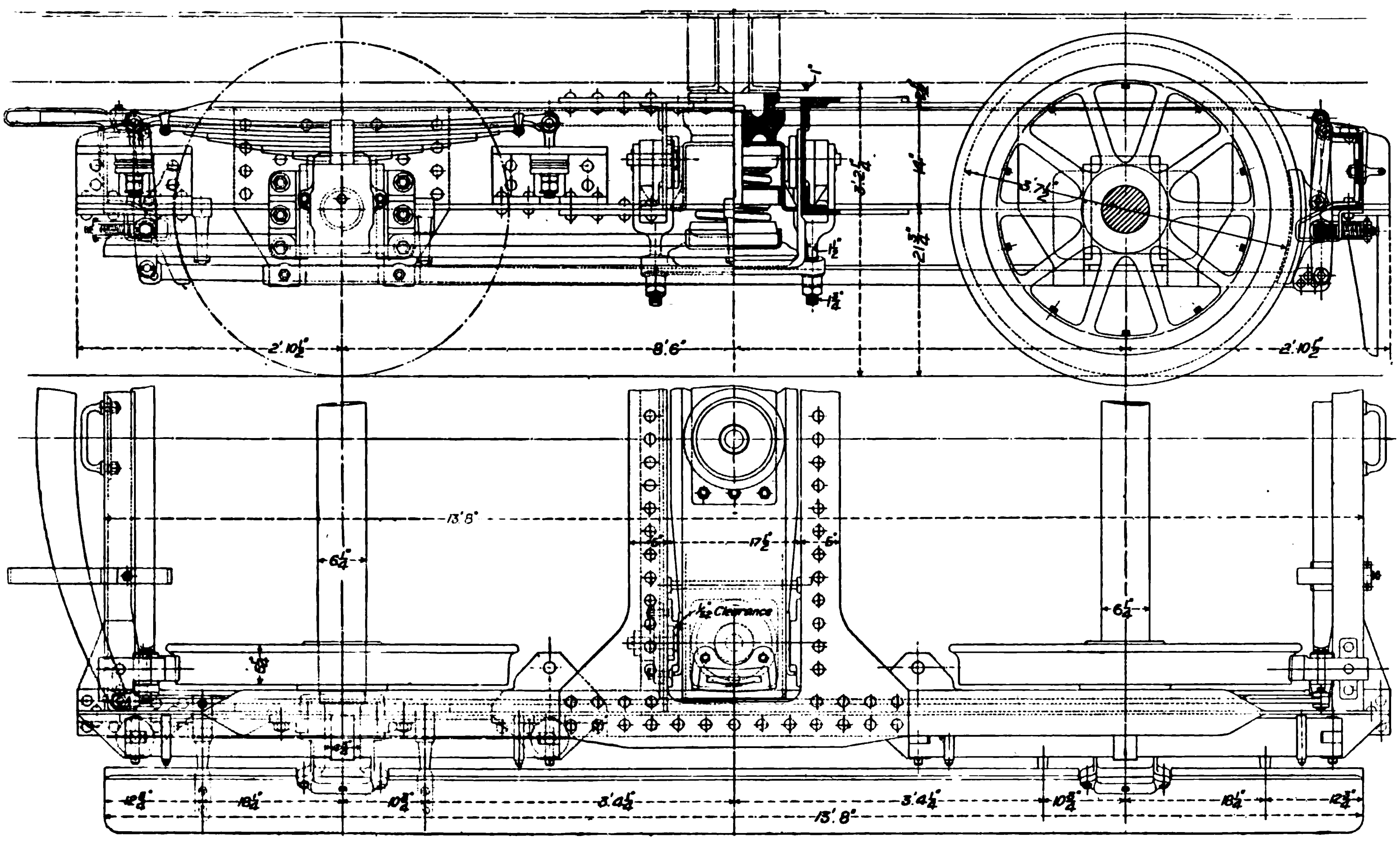


Fig. 15.—Motor Bogie.

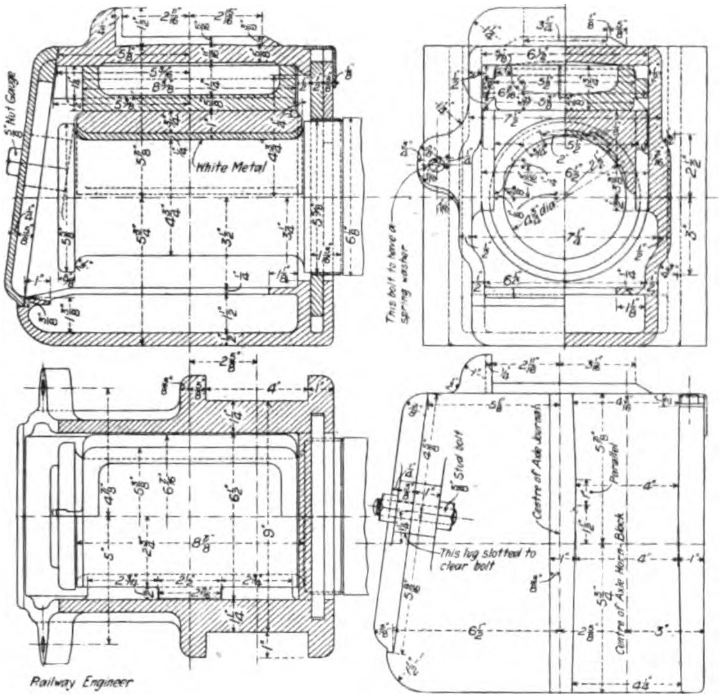


Fig. 16.—Axle-box of Motor Bogie.

throughout the operation of the train, and whether the brakes are being applied or not excepting when put on to the high speed in order to take off the brakes rapidly. The action thus corresponds exactly with the operation of the large and small ejectors on a locomotive.

The pump control gear has been specially arranged with a view to making it practically impossible for a train to be moved without proper vacuum having first been obtained as follows:—

The driver's brake valve is of special construction, figs. 17 and

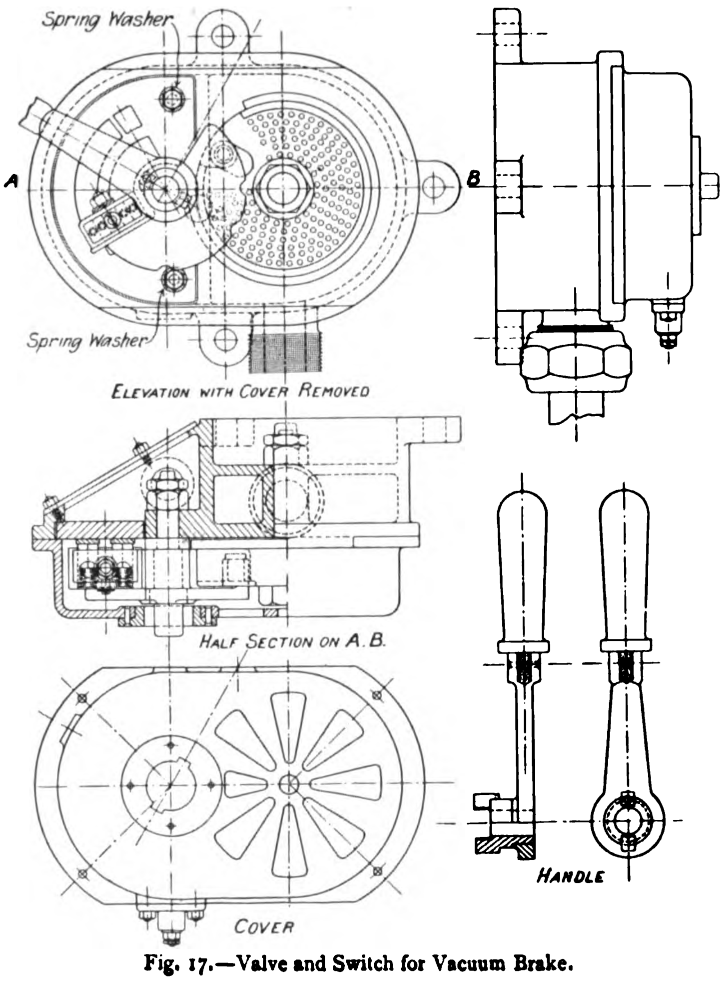


Fig. 17.—Valve and Switch for Vacuum Brake.

18, and is combined with a switch which operates the contractors controlling the pump. Current is fed up to this switch through one contact of a three-way plug, of which one of the remaining contacts is the feed wire from the auxiliary transformer and the third goes to the master controller; it is, therefore, impossible to move the car by means of any of the controllers unless this plug is inserted, and its insertion automatically operates one of the pump contactors and starts it working at either the high or the low speed; most probably the former as the driver's brake valve handle is removable, but can only be removed in full pump speed position. The use of this plug also ensures that only one controller throughout the train can be used at a time.

There is a driver's brake valve in every driving department, but it will be clear that only the valve and switch in that compartment which is being used for driving and in which the driving feed plug is inserted is operative for starting and varying the speed of the pump, but the brake can be *applied* by the guard or other authorised person who is in possession of a handle at either end of every coach.

Fig. 18.—Interior of Driver's Compartment.

There is also on each motor car an additional switch controlled by the vacuum and which will trip the main circuit breaker in the event of the vacuum falling below about 15in., this being decided upon principally in connection with emergency applications of the brake by a guard who will thus be given full control over the train, an advantage, seeing that there is only one motor man. This switch also ensures that motor men cannot start the train before taking off their brakes.

A horn, which takes the place of a locomotive steam whistle, is carried on each end of each motor car, and is electrically operated the sound being produced by the vibration of a diaphragm by means of apparatus similar, but of greater power and more substantial construction, to the ordinary trembling bell, a surprisingly loud and clear note being obtained in this way. The sound is multiplied considerably by use of properly designed trumpets obtained from Messrs. Boosey and Co., and a very satisfactory sound is produced at an expenditure of far less power and much less complication than would be the case with the vacuum operated horn, in fact, the electric horn compares well with a horn operated by compressed air. The vibrators were supplied by Messrs. Marples, Leach and Co., and are operated by a small 12 volt set of secondary batteries, the train wire for operating them being carried through the train in the ordinary train cable and through the jumpers.

For lighting, groups of six 24 volt lamps in series from the 150 volt auxiliary transformer control main are provided. The two side tail lights, however, which are electric, are each direct on the 150 volt mains, the lamps being carried inside ordinary tail lamp lanterns which are detachable and carry an

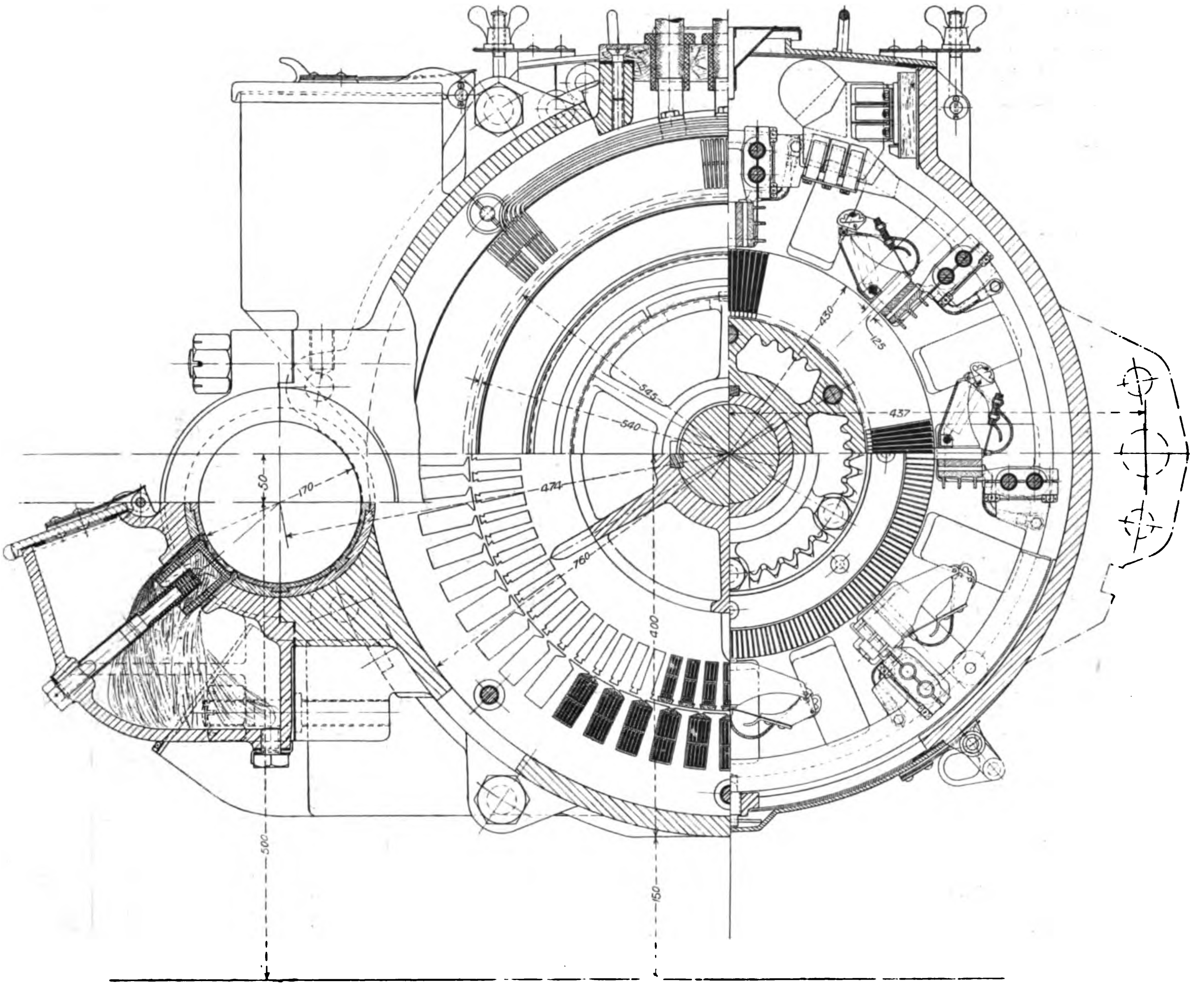


Fig. 19.—Siemens Motor.

ordinary watertight plug, the socket being fixed on the end of the coach, just above the lamp-iron. Lamp irons, plugs, and plug sockets, are provided at each end of each coach. The lamp in the driver's compartment is specially shaded so as to throw only a narrow beam of light on the vacuum gauge and ammeter, thus allowing the driver to get a good view of the road outside, his compartment being practically dark. The shade is arranged so as to be opened when occupied as a guard's and luggage compartment, or as an entrance vestibule.

In order to clear the outside of the driver's window from snow and rain a special scraper has been arranged with a handle inside the compartment so that by throwing this handle up and down the window is cleared. The scrape consists of a rubber squeegee.

The driving equipment of two of the motor cars has been supplied by Messrs. Siemens Brothers' Dynamo Works, of London and Stafford, and of the third by the British Westinghouse Co. The specification of the equipments called for 2 motors per car, both to be carried on

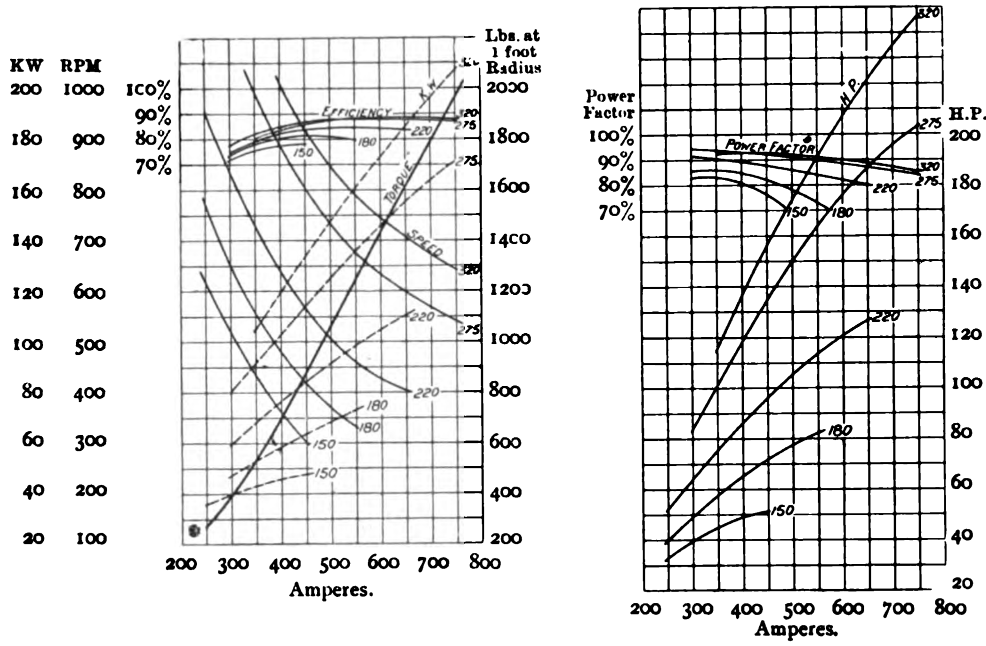


Fig. 20.—Test Curves of 175 H.P. Siemens Single-Phase Motor.

one bogie, it being considered both the more economical and the more mechanical arrangement to concentrate the motor power and reduce the number of parts as much as possible, while with single-phase traction and voltage step control there is, of course, no necessity to consider series paralleling.

The normal train was specified to consist of a motor car and two trailers, the weight of these being, without any of the electric apparatus or the mountings for the same, 25 tons for the motor car and $17\frac{1}{2}$ tons for each of the trailers. The motor car seating 72 passengers and the trailers 54, the respective standing capacity being 58 and 36, giving a total maximum capacity without encroaching on the vestibules, of 310, with a total of 180 seats. It was specified to the contractors that they would be permitted to run at 25 miles per hour round the speed restricted curves, and on this basis the trains were to be capable of working a 20 min. service from either end as between Heysham and Morecambe with a single train and a 15 min. service as between Morecambe and Lancaster under similar conditions.

The capacity of the motor car was to be such as to enable it to take on occasions two additional main line coaches weighing 26 tons each, and was also to be capable of climbing with its train the gradient from Lancaster Green Ayre to Lancaster Castle occasionally.

The additional length to Morecambe can probably still be covered for the 20 min. service if the cars be run at 25 miles per hour round the curves at the cost of a rather greater consumption of energy.

The specification also called upon the contractors, should the order for the coaches be divided, to make their equipments capable of being worked from the same master controllers, and though considerable difficulty had to be got over in order to meet this condition it was found possible to work the Siemens' equipments in conjunction with the Westinghouse one in this way.

It was considered by the Midland R. Co. that two 150 h.p. motors per motor coach would satisfactorily carry out the work, and the respective contractors supplied motors of their nearest standard sizes to this, the Siemens' motors, fig. 19, being nominally of 180 h.p. and the Westinghouse motors of 150 h.p.

The specification called for the motors being capable of delivering, when tested on the stand with single-phase alternating current of the proper periodicity, their declared output for one hour with a temperature rise not exceeding 135° F, and they were also required to have a temperature rise not exceeding 90° F. on any portion after having run the three coach train for 6 double trips as per the schedule above mentioned from Heysham to Morecambe, Morecambe to Lancaster, and return. Overload and other similar tests were also specified. The control gear was specified to be preferably all-electric multiple unit type. The Westinghouse car has, however, been accepted with their standard electro-pneumatic control modified as necessary to enable it to work with the Siemens' car, which is all-electric. Stringent guarantees of efficiency, energy consumption in watt hours per ton mile, and general performance were required to be given. The main transformer was required to conform to the same test conditions for heating as the motors, an auxiliary transformer being specified to provide for the supply of current for lighting, heating, and working the control apparatus and brake pump, this transformer having a three hour test specified, it being subject to continuous working. (See fig. 20.)

The Siemens' cars are provided with two collector bows to ensure continuous contact as far as possible. It was found impossible to get the firm's standard bow (which is of inverted pantagraph type) into the restricted space at disposal between the coach roof and over-bridges, and a type of bow has been adopted somewhat similar to the Continental tramway type of bow, but having a small auxiliary bow at the end controlled by parallel motion. This bow, while appearing somewhat simpler than the standard bow, and requiring less room, while fairly satisfactory in working, has the disadvantage that it requires balancing by a wind screen.

The Westinghouse bow is of their standard pantagraph type, a single bow only being used, and this goes into the available space fairly well.

Both makers' bows are purely spring controlled so far as their working is concerned; the Siemens' bow, however, is lowered by a master spring which can be thrown out of action by a vacuum cylinder.

The Westinghouse master spring is controlled as regards raising and lowering by compressed air, a special compressor being fitted. A small hand pump has been installed in each case for raising the bows when first starting out in the morning, or at similar times when no compressed air or vacuum is available.

The Siemens' bows can be raised or lowered separately, and

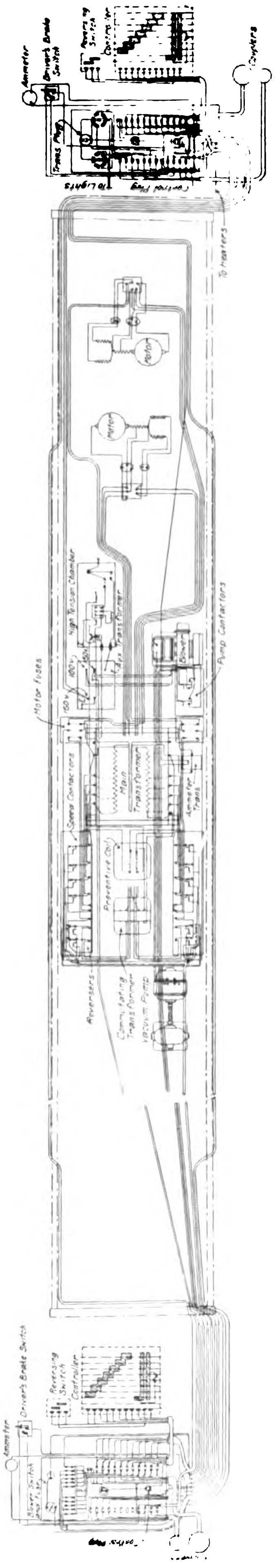


Fig. 21.—Diagram of Connections of Siemens Car.

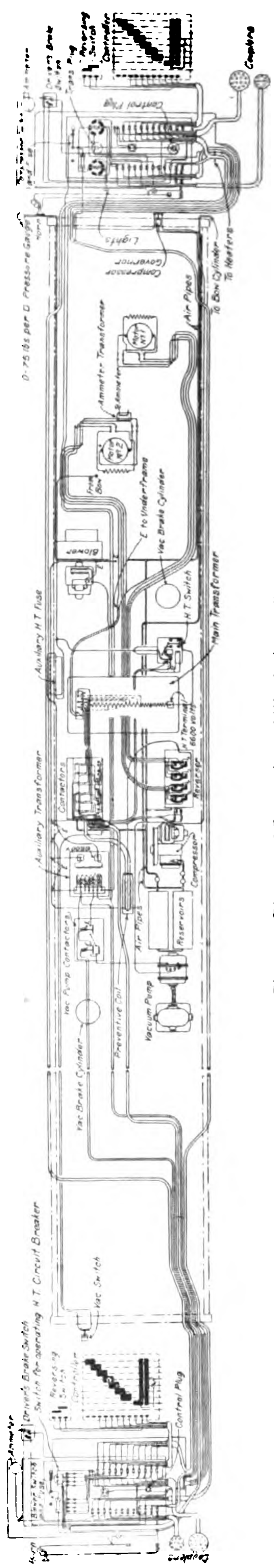


Fig. 22.—Diagram of Connections of Westinghouse Car.

the vacuum for holding them up is obtained from the train pipe through a ball valve, so that when the brakes are operated the vacuum remains on the bows.

All the "live" portions of the collector gear in each case are carried on porcelain insulators.

The roofs of all the coaches have been covered with an "earthed" wire netting so as to throw out the station circuit breakers in the event of the overhead wire coming down on the roof. The efficacy of this has been actually and satisfactorily tested in practice.

The H.T. wiring on the Westinghouse cars is carried in lead covered cable which, on the roof, is protected with a further metal covering. It is carried down about the centre of the car through a heavy section brass tube, the lead covering of the cable being sweated solid on to this tube at the top. This tubing is substantially "earthed." The further H.T. wiring to the two transformers on this car is also in lead covered cable, which again in its turn is protected in metal tubing both heavily "earthed." The cables are rubber insulated.

Except for the short length down through the coach the H.T. wiring on the Siemens' cars is, from the bow down through the H.T. chamber to the main transformer, all bare wire, being carried on porcelain insulators on the coach roof and underneath the coach. The vertical tube through the coach itself is of brass, and in this case made removable, being practically part of the wiring. The cable is paper insulated lead covered terminating above and below in bitumen sealing chambers with porcelain insulator terminations. There is about 3/16ths of an inch air space between the lead covering and the inside of the tube. Both lead covering and tube are heavily "earthed." On the Siemens' cars the H.T. wire proceeds into the H.T. chamber, the door of which is mechanically interlocked with the bows so that it cannot be opened unless the bows are down.

The L.T. wiring, though low voltage, has proved little more difficult to instal than the ordinary 600 volt wiring. Longitudinally it is carried between the two girders forming the centre members of the underframe, and it is supported between these two members in wooden frames spaced about 18 in. apart. The L.T. cables themselves are not carried in metal tubing, as probably eddy current troubles would arise if they were, but they are substantially surrounded with metal, and the coach body and its frames are all covered with sheet iron and asbestos wherever cables are run underneath. Where these tables require to go crosswise they are carried between the tops of the girders and the floor and spread out fanwise. (Figs. 21 and 22.)

The train cable is carried along the outside of the coach alongside the sole-bar in a metal tube, being carried round the bends in flexible metallic tubing. The train cable, couplers, and master controllers, for the whole of the motor cars and trailers, as well as all the pump motors and their control gear, have been supplied by Messrs. Siemens.

The Siemens' H.T. apparatus and their contractors are contained in sheet iron cases which have been made by the Railway Co. The supporting these and of the transformers, auxiliary transformer, preventive coil and other apparatus has involved the provision of a good deal of special girder work on the underframe, which has added considerably to the weight of the latter.

The Westinghouse apparatus is more self-contained though the supports for it also could probably be arranged at less expense in weight. The respective weights of the two motor coaches are as follows:—

	Siemens. Tons	cwts.	Westinghouse. Tons	cwts.
Carriage body work	13	5	13	5
Carriage bogie	4	10	4	10
Special supports	1	6	0	17
Motors with gear and gear case	6	5	5	11
Main transformer	2	14½	2	11
Aux. Com. Transformer and preventive coil ...	0	19½	0	9½
Pumps and compressors	0	9½	0	16
Contactors and chambers	1	2½	0	9¾
Other sundries, incl. bows, blowers, controllers, etc.	3	7	2	9¾
Motor bogie	6	11	6	11
Total	40	10	37	10

The Siemens' equipment consists of the two motors, fig. 19, the main transformer, the auxiliary transformer, preventive coil, and commutating transformer, H.T. circuit breaker and fuse in the main transformer circuit, H.T. fuse in the auxiliary transformer circuit, contactors, motor fuses which also act as motor cut-outs, and low tension fuses in the circuit feeding the control and also a low tension fuse in the circuit feeding the fan.

There is intentionally no fuse placed in the brake pump main circuits, the cables for which are carried in special heavy section tubing so that if anything goes wrong on the pumps the main H.T. fuse will be blown, and it will be impossible to work the car. (Figs 23 and 24.)

The apparatus was very stringently tested at the maker's works with results satisfactory in every way. At 180 h.p., and with forced draught, the motors were very much under their guaranteed temperature rise, and did not exceed this temperature rise when tested at this H.P., with natural ventilation on the stand. With forced draught, and with only 300 volts on their terminals (the full voltage being 340), they tested under the specified temperature rise at 200 H.P., corresponding at full voltage to fully 225 H.P. They were also tested for continuous operation giving at 250 volts, which was chosen as being a mean operating voltage, 105 H.P., for five hours with a temperature rise of only 115° F., so that at full voltage, allowing nothing for the improved ventilation at the higher speed, the machine can give continuously nearly 150 H.P.

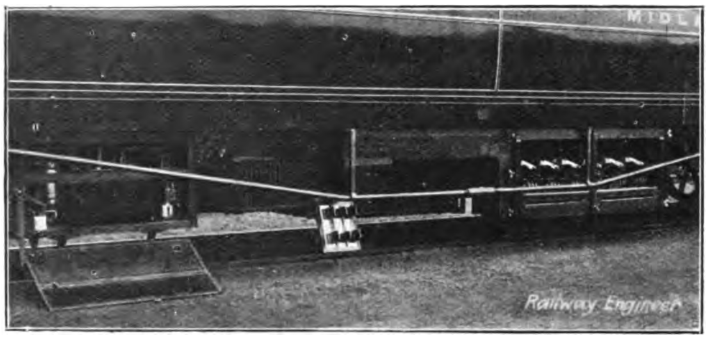


Fig. 23.—Siemens apparatus on underframe showing H.T. and contactor chambers open.

The sparking tests were equally satisfactory, there being no objectionable sparking at a current of 1,100 amps, at 300 volts, which corresponds at full voltage to 350 H.P., and a torque of fully 2⅓ times that at the rated H.P. of 180.

The commutating transformer, while apparently an additional complication, probably pays its way in effectiveness, as the sparking of these Siemens' motors, both on test and during actual running on the line, has proved to be quite as good as that of any, and better than that of many D.C. traction motors; in fact, during the testing on the line, currents of over 1,000 amps. per motor have been of frequent application without any demonstration at the commutators even just at starting the brushes on the latter portion of the acceleration, and during free running, being absolutely dark.

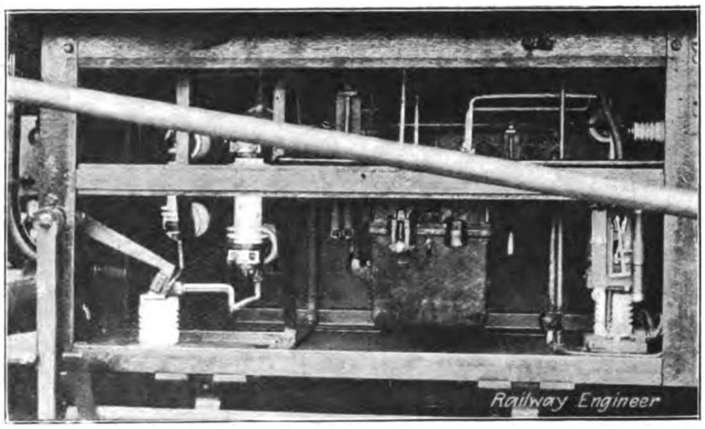


Fig. 24.—Siemens H.T. chambers open.

The operation of the contactors is also perfectly satisfactory, and gives none of the trouble that has been prophesied in various quarters for single-phase contactors in the direction of humming and chattering, excessive size, etc. though they are more liberally designed, than will probably be adhered to as standard practice.

The master controllers are, it may be mentioned, of fly-back or dead-man handle type, being, however, somewhat different from the usual design, inasmuch as the release of forward pressure on the handle by the driver trips the whole of the contactors at once, no matter on what stop the driver may be working at the moment, and without his allowing the handle to come back to the "off" position. This practically ensures the ob-

taining of the maximum amount of safety that can be obtained from a handle of this type though the occasional sudden throwing off of heavy loads in this way is a somewhat severe tax on the regulating properties of the power station.

The Westinghouse equipment consists of motors, transformer, and auxiliary transformer, preventive coil, H.T. circuit breaker in main circuit, fuses in auxiliary H.T. and L.T. circuits, contactors, and control gear. (Figs. 25 and 26.)

The motors are ordinary straight series compensated without any special commutating device other than the commutator resistance leads, the equipment as a whole being very simple but effective. The commutating performance on the line of these motors is excellent, and also as good as, if not better than, most ordinary heavy D.C. traction motors, while the commutator remains in quite as good running condition as that of any such motor.

The contactors are electro-pneumatically operated, as are also the raising, lowering, and locking gear of the bow, and to supply these parts a small compressor is installed in addition to the vacuum pump. This equipment also was tested at the makers' works with highly satisfactory results, the temperature rise at the end of an hour's full load of 150 H.P. with single-phase current being well within the limit, while overloads up to 1,200 amps, corresponding to H.P. at full voltage, and 2½

Fig. 25.—Westinghouse apparatus on underframe showing H.T. and reverser chambers open.

times normal full load torque were applied without causing injurious sparking.

The forced ventilation for the motors of both sets of cars has been fairly simple to arrange. For the Siemens' cars the suction duct has been carried inside the car under one of the seats, the whole of the air coming in this case from the inside of the car.

The Westinghouse car has a similar duct inside, but as more air is required for their motors they have also a suction duct with a filter taking air from the outside of the car.

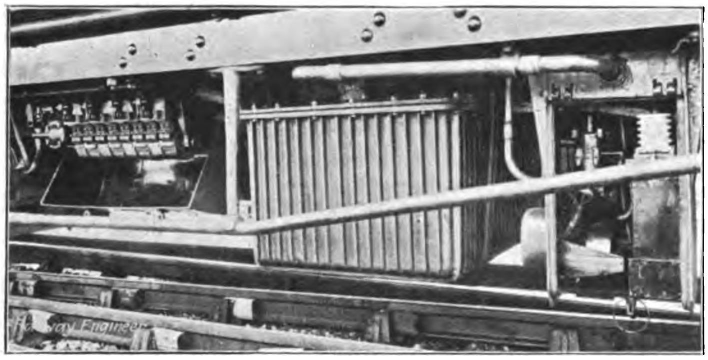


Fig. 26.—Westinghouse apparatus showing main contactor and pump contactor chambers open.

In both cases this duct comes direct into the suction eye of the fan, and the delivery duct after leaving the fan splits into two pipes, one of which crosses to the other side of the coach and comes up under the longitudinal seats on that side, thus getting across the cross-member of the underframe and coming down again above the motor, to which the air then proceeds through a rubber concertina pipe. The other half of the duct proceeds direct up under the longitudinal seat on its own side, coming down in a similar way to the other motor.

The auxiliary transformer was adopted chiefly at the instance of Messrs. Siemens with a view partly to better suiting their control gear and partly to obviating any possibility of the lights in the coaches being put out by the coming out of the overload circuit breaker in the H.T. circuit, or by any other accident which would cut off supply from the main transformer. Also, during a great portion of the year the cars will be lying in the stations for long intervals between running and an appreciable saving of energy will be effected by doing away during such stoppages with the magnetisation losses of the large transformer. On the Westinghouse car, however, at the instance of that Company, the main transformer is kept continuously energised except when the main circuit braker comes out on overload.

The auxiliary transformer might be dispensed with in cases where the cars are in continuous service, and this would also save some amount of H.T. apparatus.

On the Westinghouse car there is no interlocking of the high tension chamber with the bow, the high tension circuit breaker and fuse being put in lockfast cases, the keys of which are kept at headquarters, so that the train staff are not permitted access to these chambers at all.

The performance of the motors of these three cars both on the test bed and on the line suffices to disprove the assertion made against single-phase motors of excessive and injurious sparking. It may also be mentioned that in a test with a two-car train weighing approximately 58 tons, made incidentally in the course of ordinary running, one of the Siemens' cars attained speeds of 30 miles per hour in 41 seconds, and 48 miles per hour in 80 seconds, and the free running speed of 60 miles per hour in 160 seconds, starting, and running for 440 yards after starting, on an up-grade of 1 in 200, there being, however, thereafter about 100 yards of level, and then a down-grade of 1 in 500 for 1½ miles; this portion of the line is also very considerably curved, with curves of 30 and 40 chains radius. These tests are not the most favourable that could be obtained as the motors were not being worked to their utmost capacity. If analysed, bearing in mind that the machines are geared for "free running" at 60 miles per hour, and remembering the high train resistance at this speed, this test shows the accelerating power of the equipments to be very satisfactory.

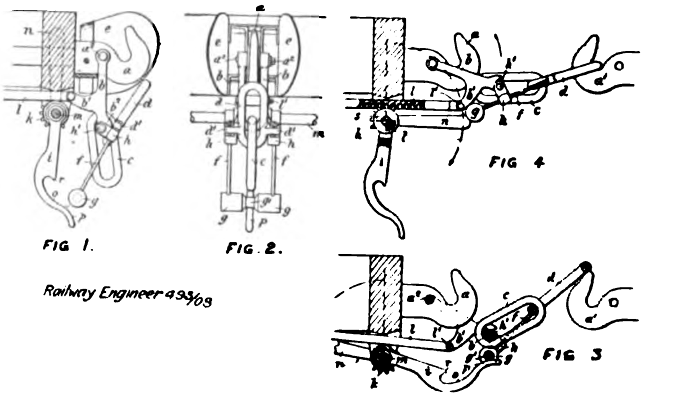
The general scheme for the electrification, the equipment of the power station, and the driving equipments of the rolling stock, were originated and planned by Mr. R. M. Deeley, locomotive superintendent of the Midland R., and his assistant, Mr. J. Dalziel. The carriages are, as above mentioned, to the designs of Mr. D. Bain, carriage and wagon superintendent, who has been assisted by Mr. P. Ellis, chief draughtsman of his department.

Recent Patents Relating to Railways.

THESE abridgments of recently published specifications are specially compiled for this review by Messrs. Wheatley and Mackenzie, Chartered Patent Agents, 40, Chancery Lane, W.C., from whom copies of specifications can be obtained at an uniform price of 8*d*. each.

Couplings (Wagon). *493. 8th January, 1908. W. Lowry, Dellabrook Cottage, Dundonald, Belfast.*

The end or hook link *d* of a three link coupling is slidably and pivotably connected with the draw-bar link or shackle *b*, by rods *f* sliding in pivoted blocks *h*, and is provided with an over-balancing weight *g*, so that on raising the end link by suitable mechanical means, the link slides in its shackle connections and raising the shackle arrives in a position when the over-balancing effect of the weight is overcome by the weight of the end link, which there-

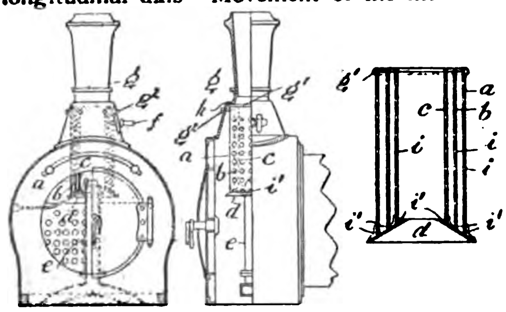


upon drops over the draw hook of the next wagon and the coupling is effected. To uncouple, the drawbar link or shockle *b* is raised by suitable mechanical means until it engages the weight which, acting in conjunction with the shackle connections on the end link, supports the end link in an extended position until it is raised from the draw hook, when the end link slides in its shackle con-

nections; the coupling is then allowed to resume its normal position. The operating mechanism comprises an arm *i* for actuating the link *d* through the weight *g*, and a toothed pinion or sector *k* and rack bar *l* for actuating the link *b*. The arm *i* is mounted on a cross bear or shaft *m* which is carried in suitable bearings fixed to the wagon and provided with a hand lever *n* at each end at the side of the wagon. The arm *i* is formed with a concave curved part *o* and a convex curved part *p*, both of which parts engage with an annular groove or reduced part g^1 formed at the middle of the weight *g*. When the shaft *m* is rotated the part *o* strikes the groove g^1 of the weight in a tangential manner and causes the weight to rise vertically rather than swing about the pivotal connections a^2 of the link *b* and therefore slide the rods *f* through the blocks *h*. This initial vertical motion is particularly useful when through the fracture of the drawbar springs, the hooks are more adjacent to each other than is normally the case. The part *p* serves to continue lifting the weight until the link *d* has dropped over the hook a^1. (*Accepted 19th March, 1908*).

Spark Arrester. *27,133. 7th December, 1907. W. J. Neath, 80, Crescent Road, Plumstead, London, S.E.*

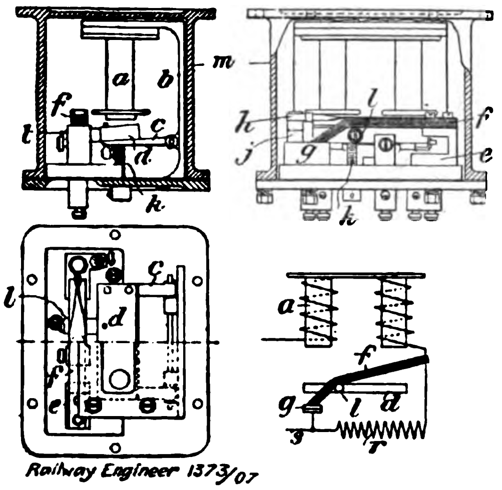
The spark-arrester is composed of three cylinders, *a*, *b* and *c* placed one within the other in spaced relation. The outer cylinder *a* and the inner cylinder *c* are fixed to a cone-shaped plate *d* through which passes the upper end of the blast pipe *e*, while the intermediate cylinder *b* is left free so as to be movable round its longitudinal axis. Movement of the intermediate cylinder *b* may advantageously be effected directly by a handle *f* working in slots formed in the outer cylinder *a* and the base of the funnel or chimney *g*, or indirectly in any well known or approved manner by a lever suitably located on the footplate of the engine. The cylinders extend upward to near an annular shoulder *h* provided interiorly of the base of the funnel *g* and are secured by screws g^2. A ring-plate g^1 is provided at the top of the cylinders to closure the annular spaces formed between them. The three cylinders are provided with holes *i* suitable for the size of the engine, each cylinder having a lower circumferential row of semi-circular or substantially semi-circular holes i^1 and being spaced an equal distance apart, the distance varying with different areas of funnels. In use the cinders strike against the cylinders and fall on the cone shaped plate *d*, from whence they pass through the holes i^1 to the bottom of the smoke box. (*Accepted 26th March, 1908*).



Railway Engineer 27133/07

Electric Lighting of Trains. *1,373. 18th January, 1907. C. A. Park and C. L. Mason, London and North Western Railway Carriage Works, Wolverton.*

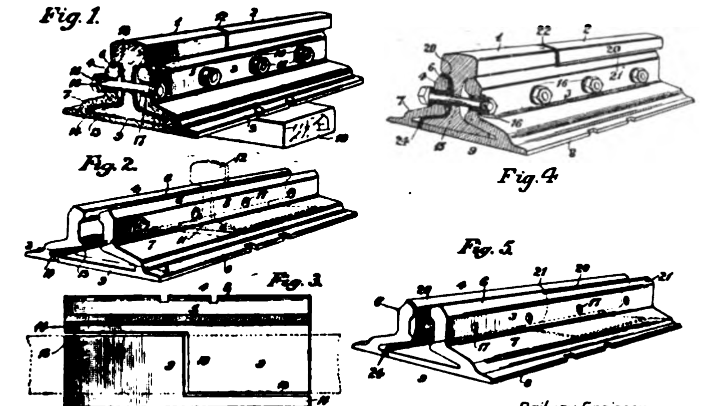
In order to prevent excess current from being generated in electric train lighting systems, provision is made for the insertion of a resistance into the armature circuit by means of an electro-magnet in connection with the main circuit whenever the electro-magnet is energised by a predetermined maximum current strength. The magnet *a* is conveniently fixed to a standard *b*, to which are pivoted lever arms *c* carrying armature *d*. Upon a block *e* is fixed one end of a brush *f* whose free end normally bears upon a contact block *g*. A carbon brush *h* is suitably provided on *f* for the purpose of contacting with the carbon block *j* and receiving the spark in the known manner. An adjustment screw *k* is provided for regulating the distance of the armature *d* from the poles of the magnet. A pin or stud *l* projects from the edge of the armature and takes beneath the brush *f*. A casing *m* encloses the parts and is provided with suitable terminals and connections to enable the apparatus to effect the following functions best understood by reference to the diagram figure 4. A resistance *r* is placed in shunt with the switch *f g* so that the current from the armature passing through the windings of the magnet *a* and arriving at the brush *f* in the closed position mostly passes there through to the contact block *g* and to the wire *s*, although of course a very small portion will flow through the resistance *r*, which before was short circuited is now inserted in the armature circuit and effects a reduction in the current flow. In order to counteract such a contingency as may occur when employing this apparatus in connection with Stone's system, in which the armature revolves at a constant speed, as for example when the speed of the train is great and the degree of slipping may be excessive, the putting in of the resistance acts to increase the voltage of the dynamo as well as to reduce the current flow, thus the speed of the dynamo is increased and the excessive amount of slip reduced. (*Accepted, 18th March, 1908*).



Railway Engineer 1373/07

Insulated Rail Joints. *24,770. 8th November, 1907. Date claimed under Patents Act, 1901, 8th November, 1906. B. Wolhaupter, 29, West 34th Street, New York City, U.S.A.*

The fish plates 3, 4 have head and foot flanges 6, 7 and inwardly projecting base plates 9, which form separate supports for the rail ends. A space 10 is left between the adjacent edges of the plates 9, which is designed to be suitably insulated preferably by the base 11 of the insulating end post 12. The longitudinal edge 13 of each base plate 9 is arranged in parallelism to and spaced from a narrow girder or trussing flange 14 projected inwardly from the lower edge of the foot flange 7 of the directly opposite side plate. This narrow girder flange or trussing flange 14 is the portion of the metal left by the shearing or casting operating along the non-supporting end of the side plate, that is along that end portion of the side plate which is not provided with a base plate for a rail end. By reason of this construction the flange portion 14 of each side plate forms a narrow continuation of the base plate and reinforces and trusses the latter. When the side joint plates are applied and the several joint bolts 15 tightened, a well defined space is left between the longitudinal edge 13 of each base plate and the directly opposite girder flange 14 of the opposite side plate. This space ordinarily provides an air gap of sufficient width to secure proper insulation at this point in the base structure of the joint. The joint bolts 15 may be insulated by employing the flanged or headed insulating bushing 16 fitted in the bolt holes 17 of the plates 3 and 4, and whose flanges or heads are interposed between the heads and nuts of the bolts and the outer faces of the side plates. To complete the general insulation of the joint, continuous side insulating sheets 18 are interposed between the sides of the rails and the rail adjoining faces of the joint plates 3 and 4. Instead of the continuous sheets 18 shorter sheets 20 may be arranged to extend just over the insulation 22 between the ends of the rails, Fig. 4 and 5, and also to extend as indicated at 24 into the space between the flange 14 and the edge 13 of the base plate 9. (*Accepted 5th March, 1908.*)

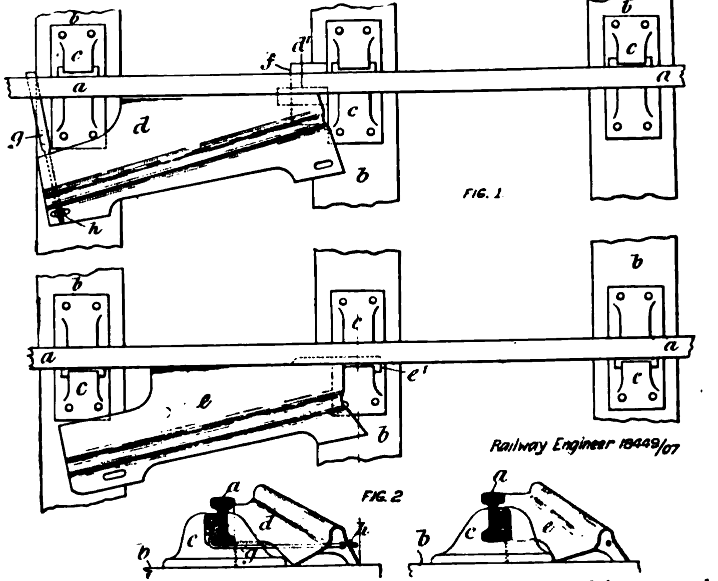


Railway Engineer 24770/07.

Re-railing Ramps. *18,449. 15th August, 1907. A. P. Turner, 15, Friars Road, Ipswich, and F. W. W. Pickance, 16, Aspland Road, Norwich.*

The ramps *d* and *e* are formed of pressed steel or other suitable material, or iron plates, long enough to take a bearing on two sleepers *b*, and constructed so as to be fixed one against the outside of the outer rail, and one against the inner side

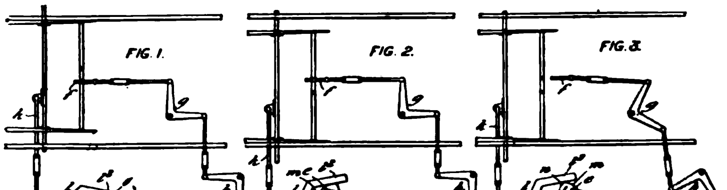
of the opposite rail, each ramp having a projecting portion d^1 c^1 on the side nearest to the rails *a*, which fits into the recess between the top and bottom flanges, and is continued in the form of a dowell or key projecting from the pointed end of the ramp the dowell or key e^1 being inserted into the cavity of the rail chair in place of the ordinary wood key, and thus firmly securing the ramp in position, without placing any obstruction on the rail surface, and thus the whole or any part of the train may be drawn or propelled over the metals to which the ramps are fixed, the inclined surface of the ramp terminating close up and flush with the top surface of the permanent rail as shown



at the right hand side of Figure 2. The inside ramp *d* is secured in a like manner by the projecting dowell or key d^1 fitting into the cavity of a temporary clip *f* similar to a rail chair reversed, which is brought under the rail and placed as near as possible to the fixed ordinary chair *c*. An ordinary rail chair reversed could be used for this purpose if necessary. The inclined surface of the ramp *d* when in position does not reach up to the top of rail by a distance slightly less than the depth of a wheel flange, as shown at the left hand side of Figure 2. If additional security be desired the free ends of the ramps may be held in position by anchor stays *g*.—(*Accepted 5th March*, 1908).

Point Mechanism. 15,959. *11th July, 1907. Siemens Brothers and Co., Ltd., 12, Queen Anne's Gate, Westminster, and W. Bourne, 4, Church View, Didcot, Berkshire.*

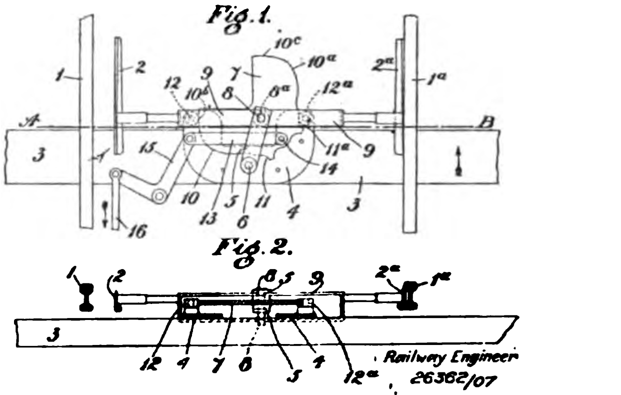
This invention consists in an arrangement in point moving and locking mechanism, whereby the points are moved during a portion only of the revolution of the operating shaft, and are at rest whilst the locking plunger is withdrawn or inserted in the stretcher box. A cam *b* is keyed to the operating shaft *a* and revolves between the arms l^1 l^2 of a lever *l* central at l^3. The connecting rod *d* is pivoted at *e* on the bisecting line of the cam and transmits the motion of the crank arm *a—e* to the plunger *f*



through suitable bell cranks *g*, *h*. The arm *i* of the lever *l* is connected with the points by the link *k*. The position of the parts being that shown in Fig. 1, when the shaft *a* is rotated in the direction of the arrow the crank arm *a—e* moves the plunger *f* so as to withdraw it from the stretcher bar, but no movement of the lever *l* occurs because the edge *m* of the cam *b* is a circular arc, the centre of which is in the axis of the shaft *a*. By the time the plunger has been fully withdrawn the edge *m* has left the arm l^1 of the fork against which it was moving and the corner *n* has come against the arm l^2. The lever *l* is now moved to bring the points into their other extreme position the plunger *f* being meanwhile moved still further from the stretcher bar and returned through the same distance. The position of the parts is now that shown in Fig. 3, where the radial surface *m* is beginning to move against the arm l^3. The lever now makes no further movement, but the plunger *f* is returned into locking position, the final position of the parts being that shown in Fig. 2. (*Accepted 5th March*, 1908.)

Point Mechanism. 26,362. *28th November, 1907. A. G. Kershaw, and Saxby and Farmer, Ltd., 53, Victoria Street, Westminster.*

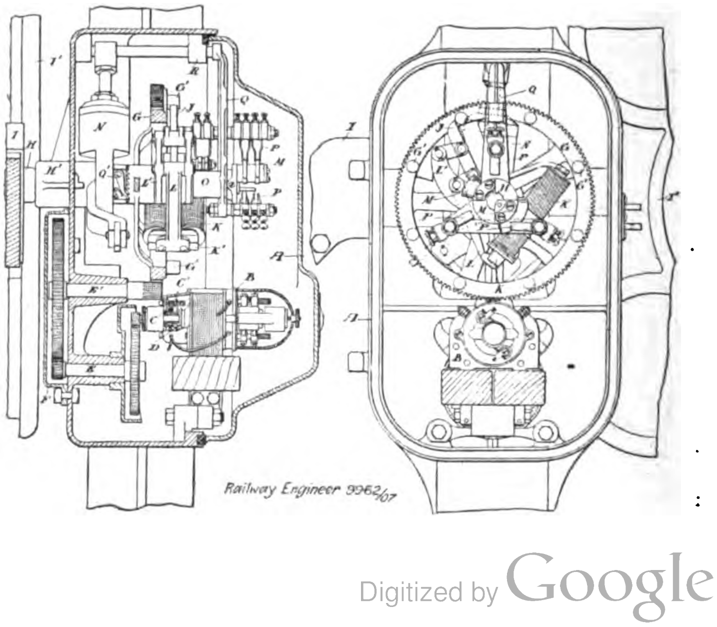
This apparatus consists of a rotary cam 7 carried by, or acting on, a stretcher bar and adapted to act on one or other of a pair of rollers 12, 12^a mounted on pivots fixed to the permanent way, the cam being so arranged that it moves or travels bodily with and in the same direction as the points, and that its operating con-



nection also moves in the same direction as that in which the points move. This arrangement results in a very considerable reduction of working friction compared with known arrangements. The cam 7 is carried on a radial arm 5 and is pivoted on a pin 8 which passes through slots 8^a in the stretcher bar. One end of each face 10, 10^a is formed as a circular arc struck from the centre of the pivot 8 as shown at 10^b, 10^c, the other ends of such faces being concavely formed as shown at 11, 11^a. The cam is operated, or rotated, by the movement of the connecting link 13, one end of which is pivotally connected at 14 to the cam 7, the other end of such link 13 being connected, for instance, to crank 15. This crank 15 receives motion from the lever in the signal, either through a direct rod connection, or through a rod such as 16 connected to and moved directly by the movements of a safety bar or facing point lock. Although it is preferred to mount or carry the cam 7 in a radial arm such as 5, and thus relieve the stretcher bar of the side strain, yet such an arrangement is not absolutely essential. In another arrangement of the apparatus the radial arm 5 is omitted, and instead of carrying the cam 7 on an arm, as in Fig. 1, the cam is pivotally mounted on the stretcher bar itself. (*Accepted 5th March*, 1908.)

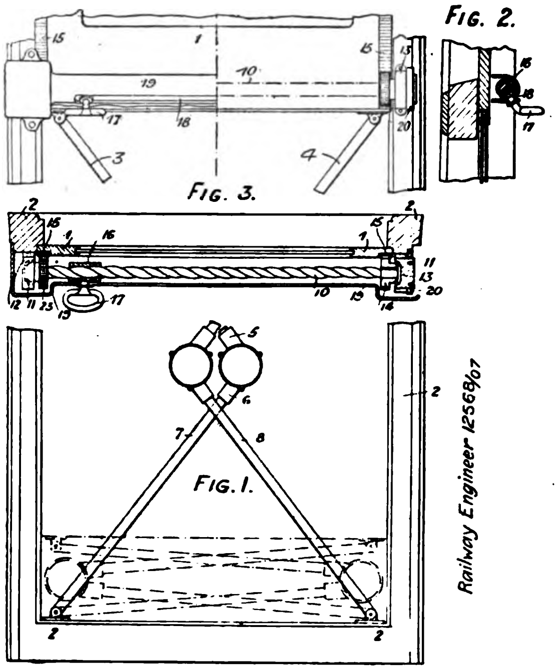
Electrically Operated Signals. 9,962. *29th April, 1907. The British Thomson-Houston Co., Ltd., 83, Cannon Street, London (a communication from the General Electric Co., Schenectady, New York, U.S.A.).*

This invention relates to semaphore signals in which the operating mechanism and electric motor are enclosed in a casing surrounding the semaphore shaft. The motor B is provided with an electric brake C, the coil of which is connected in series with the motor. The parts are shown in the positions which they occupy



when the motor is in the act of driving the semaphore arm from danger to clear, so that the brake-coil C is shown energised, attracting its armature C^1, and holding it away from the brake disc D on the motor shaft. When the motor circuit is broken the armature C^1 is released and is pressed by its springs into engagement with the brake disc D. Consequently, whenever the motor is de-energised, all parts that are geared to it are held fast by the brake. The motor shaft carries a pinion which engages a gear on an intermediate shaft E. This shaft is journalled in a stud or boss formed in the wall of the casing itself, and carries a pinion at its end outside the casing. This pinion engages a gear on a second intermediate shaft E^1, which is similarly journalled in the wall of the casing and carries a pinion inside the casing. A gear-case F covers the gear and pinion outside the casing, and protects them from the weather. For controlling the motor B and the magnets K, contacts M are mounted on the shaft H. A sleeve O is placed on the shaft H carrying contacts P co-operating with the contacts M on the shaft. To prevent rotation of the sleeve, which carries the contact M, an arm Q is provided which engages the casing. For the purpose an arm R projecting from the casing is provided with a socket into which a pin on the end of the arm enters. By means of this construction the necessity for supporting standards or brackets inside the casing is avoided, and the size and cost of the signal reduced. The pinion on the intermediate shaft E^1 engages gear-teeth on the periphery of a drive-wheel G, which is loosely mounted on the shaft H, which is journalled in a boss H^1 in the wall of the casing and carries the signal arm I and its counter-weight or spectacle casting I^1. For driving the signal to clear position the drive wheel G is clutched to the shaft H by a slot mechanism comprising a locking piece J adapted to engage protecting studs G^1 at the periphery of the drive-wheel, controlled by the actuating magnets K by means of a bell-crank lever L, which is pivoted on an arm L^1 fast to the shaft H, and which carries at the end of its short-arm an armature K^1 for the magnets K, and at the end of the short-arm is connected to the locking piece J. When armature K^1 is attracted by the magnets K the locking piece J is thrust outward into the path of the studs G^1, one of which is shown in engagement with the driving piece, so as to drive the shaft H. When the magnets are de-energised the armature K^1 falls away withdrawing the locking piece J, so as to disengage the shaft from the drive-wheel, and to allow the signal to go to danger. A dash-pot N is provided for retarding the movement of the signal when it is carried to danger by its counter-weight. In order to prevent the signal-arm from being carried to clear position from any cause, except when the motor is operating, a spring-pressed pawl Q^1 is provided on the shaft H and ratchet-teeth on the hub of the drive-wheel G adapted to be engaged by the pawl. When the motor is operating to drive the signal to clear, as shown in the drawings the rotation of the drive-wheel G for this purpose being counter-clockwise, as viewed in Fig. 2, the ratchet and pawl are inoperative, since they are carried along together by the engagement between the locking piece J and a stud G^1 on the drive-wheel. When the slot magnets K are de-energised to allow the signal to go to the danger the pawl and ratchet device still remains inoperative, since the rotation of the shaft, when the signal is moved toward danger position, is clockwise as viewed in Fig. 2, so that the pawl Q^1 slips idly over the ratchet-teeth. But as soon as the signal reaches danger poition it is locked there by the pawl Q^1, which prevents any movement of the semaphore-arm relative to the drive-wheel in the opposite direction, while the drive-wheel is prevented from all movement whatever by the brake on the motor shaft, which is now released by its coil. Consequently the semaphore-arm is locked at danger position, and cannot be moved to clear until the motor is energised to drive it, at which time the brake coil C is energised and the drive wheel G driven by the motor. (*Accepted 12th March*, 1908.)

Carriage Windows. *12,568. 30th May, 1907. R. T. Preston, of J. Stone and Co., Ltd., Deptford, London, and A. A. Mead, Aldersyde, Lansdown Road, Lee, Kent.* The sash 1, which is guided in grooves in the stiles of the carriage door, is supported on and balanced by a lazytongs device below it, consisting of two links 3 and 4 jointed at their upper ends to the bottom rail of the sash and crossing each other, these links being at their lower ends attached each to one part 5 of a fusee spring box, while the other part 6 of the box is attached to the upper end of links 7 and 8, which at their lower ends are jointed to the door 2. The fusee spring is so fitted as to force the two parts 5 and 6 of the box from each other so that the centres of the two boxes tend to approach each other, that is to say, to raise the sash 1 or to balance its weight or more or less so. Or, as an alternative arrangement, the sash may be hung in metal bands or chains, passing round and fixed at one end to fusee spring boxes mounted one at each side of the door frame in the corner above or, at least, preferably not below the sash, and at the other end attached to the sash, the springs balancing the sash or nearly so. For raising and lowering the window a steep-threaded screw spindle 10 is mounted horizontally in bearings on the door, preferably ball bearings, where the balls 11 are placed at one end in a socket 12, forming part of the ball race, and at the other end in a screwed socket 13, forming part of the ball race which socket is suitably screwed so as to permit of adjustment, and locked by



means of a locked nut 20. The other part of the ball bearing is made in one with a pinion 14 fixed on one end of the screw spindle 10, which at its other end has mounted thereon the pinion 23. These pinions 14 and 23 gear each with a toothed rack 15 on the sash 1. A nut 16 formed with a handle 17 engages with the screw 10, and will, when pushed in one direction or the other, raise or lower the sash, the nut being guided by the shank of its handle 17 in a slot or chase 18 in a sheet metal casing 19 which cover the screw and the pinions and is fastened on the carriage door. Or the nut may be made to embrace merely one half of the screw spindle. (*Accepted 12th March*, 1908.)

COMPLETE SPECIFICATIONS ACCEPTED.

1906.

19378A. Electrical signalling apparatus for use on and in connection with railway locomotive engines and the like. Bounevialle.

29398. Apparatus for recording the time of signals on railways and the like Hewitt.

1907.

1373. Electric lighting of railway and other vehicles. Park and Mason.

1596. Electrically-operated switches specially applicable to railway and other vehicles. Park and Mason.

6135. Signalling systems for railways and the like. British Thomson-Houston Co.

6992. Electric railway signalling apparatus. Notarianni.

7138. Brake mechanism for railway wagons and the like. Riley, Spiers and Strettell.

9324. Railway signals and gates. Combs and Combs.

9962. Electrically operated signals. British Thomson-Houston Co.

10087. Railway sleepers and means for attaching rails thereto. Willis.

10883. Hand-operated brake-gear for railway waggons. Hill.

12435. Apparatus for actuating signals on railway engines and the like from the track. Carr.

12568. Railway carriage windows and the like. Preston and Mead.

13859. Means for excluding water or the like from the windows of railway carriages, motor and other road vehicles, ships and other purposes. Le Maitre.

15636. Automatically-operated station indicators for electric railways. Daley and Daley.

15826. Atmospheric blower for locomotive engines and the like. Goldie.

15959. Mechanism for moving and locking railway or like points. Siemens Bros. and Co. and Bourne.

18449. Ramps for re-railing rolling stock, locomotive engines, or tenders, on all railroads constructed with chairs. Turner and Pickance.

18836. Railway rail joints and ties or sleepers. Hindman.
19030. Railway fog-signalling or the like. Angeloff.
19466. Spark arresters. Lamb.
21198. Railway signals. Johnston.
22053. Dust shield for axle-boxes for railway vehicles and the like. Leishman
24016. Means for operating the sliding doors of hopper wagons. Ullmann.
24770. Insulated railway rail joints. Wolhaupter.
25819. Supporting guides or antifriction rollers for the operating rods of railway switch points and the like. Dunkerton and Saxby and Farmer, Ltd.
26362. Apparatus for working and locking railway and like switch points. Kershaw and Saxby and Farmer, Ltd.
27133. Spark-arrester and draught-regulator for locomotives and like engines. Neath.
28202. Railway rail joints. Steele.

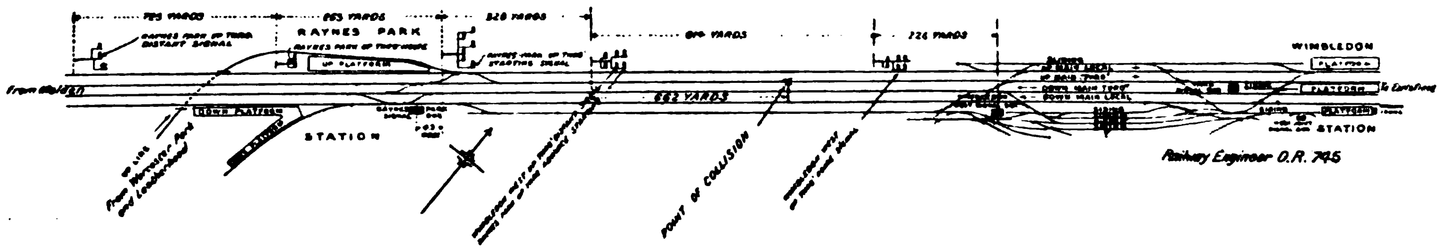
1908.

493. Coupling for railway coaches, wagon, and the like. Lowry.

Official Reports on Recent Accidents.

Near **Wimbledon, L. & S.W.R.** *On the 23rd January Major J. W. Pringle reports that:—*

The 4.18 p.m. slow train (engine and eight 8-wheeled coaches) from Leatherhead to Waterloo, was run into during a dense fog by the following train (engine, tender, and 12 vehicles fitted with vacuum brake), the 1.55 p.m. from Southampton. The first train was driven forward about 20 yards. The adjacent ends of third and fourth vehicles on the Southampton train were smashed in. The guard and 24 passengers were injured.



The site of this collision is shown on the diagram.

This collision was due to driver Bartlett, who, although warned by a detonator that the distant signal for the up through line at Raynes Park was at danger, failed to reduce his speed in accordance with the general rules, and consequently did not observe the danger position of the home, starting, and advanced starting signals. Although the main responsibility falls upon his shoulders, it is difficult to find adequate excuses for the failure of guards Francis and Barlow, to take some action to check the speed of the train, after the detonation which they all heard at the distant signal post. Francis admits that he saw fogman Gray's red hand light, and he should have recognised that the speed of the train was not being reduced to the extent required by the rules. It is possible that Bartlett, fireman Tribbick, and Francis, by reason of their positions at the head of the train, might not have recognised the two additional detonations fired by fogman Bates as danger signals applicable to their train. But Barlow, who rode in the centre of the train, if he had been alert, should surely have recognised the additional explosions as taking place under his train, in which case he ought to have acted in accordance with Rule 177 *(b)* and applied the brake.

Bartlett had been on duty about 5 hours, and had previously been off duty for about 12 hours. He has a good character and record for 15 years.

*

Near **Preston, L. & Y. & L. & N. W. Joint R.** *On the 4th February. Lt.-Col. E. Druitt, R.E., reports that:—*

The L. and N.W. 6.5 a.m. passenger train from Liverpool was run into by a light 6-coupled tender engine. Seven passengers were injured.

Between No. 1 box at the south end of Preston Station and Ribble Sidings box, a distance of 579 yards further south, the lines run north and south, the up lines being on the east side of their respective down lines. The lines are, from east to west, up and down fast, up and down slow, and up and down through, a shunting line and sidings.

A little to the north of Ribble Sidings signal-box there are connections leading from the up through line to the up slow line, and from the down slow line to the down through line.

Just opposite the signal-box there are connections leading from the up slow to the up fast line, and from the down fast to the down slow line.

To the south of the signal-box the fast lines are still on the east side, but then come the up slow and up loop, and then the down slow and down loop, so that the continuation of the up through line leading to the up slow and to the up loop line crosses the down slow line.

The points known as No. 31 in the evidence are the trailing points in the up slow line where the up through line terminates. The facing points in the up slow line leading to the up loop line are just beyond No. 31 points which lie normally for the up slow line, and when they are pulled over for the up through road.

It is impossible to interlock the points No. 31 with the points both of the down slow line, and with those of the crossing from the down fast to down slow line, because if the latter were interlocked with No. 31 it would be impossible to use the main crossing from up slow to up fast line (which requires the down fast to down slow crossing to be pulled over first) at the same time as the down slow line.

The distance from No. 31 points to the diamond crossing of the down slow line and up through line is 45 yards, and to the diamond crossing of the up slow line and down fast to down slow connection is 35 yards.

A light engine arrived on the up slow line at Ribble Sidings signal-box at 7.53 a.m. where it had to be crossed on to the up fast line as the sidings at Farington are connected to that line.

Signalman Wilding could not at once let the engine on to the up fast line as several express trains were due to run on that line, and the up slow line was required for the Fleetwood boat express to London. Accordingly Wilding determined to shunt the light engine back on to the up through line until he could get the up fast line clear for it, so he sent the engine to No. 31 points, which he reversed, although he knew that by doing so he set the road so that the light engine could set back foul of the passenger train then approaching on the down slow line, and driver Heyes considering that the verbal instructions given him by Wilding were sufficient authority for him to set back without receiving a hand signal, at once reversed his engine and set back towards the up through line, and did not see the passenger train in time to prevent a collision at the diamond crossing of the down slow line and up through line, the distance he had to travel being only 45 yards. The approach of the passenger train was obscured from No. 31 points by an engine and van at the dead end of the up loop line.

It is impossible owing to the condition of traffic at the signal-box to lock No. 31 points with the other crossing points so as to protect both the down slow line and the connection from the down fast to the down slow line in the case of any engine improperly setting back through No. 31 points, but in this case there was no necessity for Wilding to pull over No. 31 points until after the passenger train had gone clear.

The movement he proposed to make with the engine was not a proper one, and has now been prohibited.

Wilding as a rule is the second man in charge of the Ribble Sidings signal-box, but as his mate was sick he was acting as signalman in charge at the time of the mishap. He had been at this signal-box 7 or 8 years. He had been on duty for just under 2 hours after an interval of 16 hours.

*

Near **Huddersfield, L. & N.W.R.** *On the 13th January. Lt.-Col. E. Druitt, R.E., reports that:—*

The 3.2 p.m. L. and Y. passenger train (engine and 3 bogie coaches fitted with vacuum brake) from Huddersfield ran into the rear of the 1.55 p.m. L. and N.-W. fast passenger train from Manchester.

The two rear vehicles of the L. and N.-W. train and the engine of the L. and Y. train were derailed; 14 passengers, both the drivers, the L. and Y. fireman, and the L. and N.W. guard were injured.

When the L. and N.W. train left Huddersfield at 2.55 p.m. it proceeded to the home signal at Hillhouse No. 1, which was found to be at danger, so the driver S. Haley states he whistled, and after waiting at it for a few minutes sent his fireman, W. Irwin, to the signal-box a distance of 211 yards ahead to remind the signalman in accordance with Rule 55. Just as Irwin reached the signal-box he heard his engine give a short whistle, and saw the train coming on, so he did not then go into the signal-box. The L. and N.W. train had been standing some four or five minutes at the home signal and had not been noticed by the signalman in Hillhouse No. 1 box as it was foggy at the time, and a train shunting on the goods line adjoining the box had apparently prevented Kirkbright hearing the passenger train whistling. According to his own statement he had no reason to expect a train to be waiting as he says he only got "Entering section" signal at 3.4 p.m., when he at once offered the train to the box in advance, and it being accepted, he at once lowered all his signals for it.

As soon as the home signal was lowered, the driver drew forward slowly towards the signal-box to pick up his fireman, and just as he reached it his train was run into from behind by the L. and Y. train, which was thus running with all signals off for it. The evidence of the signalmen concerned is conflicting, the collision being due to a mistake on the part of one of them.

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Telephone No. 8334 Holborn.

THE
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Contents.

Among the "Birthday Honours" were a baronetcy conferred on **Sir Robt. W. Perks, M.P.**, formerly solicitor to the Metropolitan Railway, and subsequently chairman of the Met.-District Railway; a K.C.M.G. for **Mr. T. R. Price**, late general manager of the Central South African Railways, and formerly of the Cape Government Railways; and a peerage for **Mr. J. W. Philipps, M.P.**, chairman of the Buenos Ayres and Pacific and other South American Railways, and who has decided to adopt the title of **Lord St. Davids**.

Col. John R. Wright, deputy-chairman, has been elected chairman of the Port Talbot Railway and Docks in place of **the Earl of Dunraven**, who has resigned the position as he yas not able to give the necessary time to the affairs of the Company.

Sir Philip F. Rose, Bart., for many years solicitor to the London, Brighton and South-Coast Railway, is retiring from practice, and has been elected a director of the company in succession to the late **Mr. Wm. Milburn**, and his son, **Mr. P. Vivian Rose**, has been appointed to succeed him as solicitor to the company.

Mr. John H. B. Noble, of Jesmond, Newcastle-on-Tyne, has been elected a director of the North-Eastern Railway.

Major J. C. W. Madden has been elected a director of the Great Northern Railway of Ireland.

Col. A. J. Filgate, R.E., has been elected a director of the Rohilkund and Kumaon Railway.

Major H. C. Cusack, deputy-chairman of the Midland Great Western Railway, has been appointed to represent the company on the Board of the Sligo and Arigna Railway and Mining Co., the Bill for the construction of which is passing through Parliament unopposed.

Mr. J. Shaw, resident engineer of the Mersey Railway, has been appointed general manager, and **Mr. R. Bowman Smith**, the present traffic manager, has resigned, but his services will be retained until the end of the year.

Mr. E. T. Lawrence, secretary of the Midland and South-Western Junction Railway, has been appointed secretary of the Barry Railway in succession to **Mr. W. Mein**, who has resigned on account of age.

Mr. Robt. Brown has been appointed goods superintendent of the Caledonian Railway at South Side Station, Glasgow.

Major Lincoln Sandwith, formerly of the 8th Hussars, and who commanded the 15th Battalion of the Imperial Yeomanry in the South African War, has been appointed superintendent of police of the Midland Railway.

Mr. Alex. Black, coaching plant inspector, Caledonian Railway, has been appointed assistant station superintendent in succession to Mr. Newlands.

We regret to record that **Mr. W. R. Sykes**, jun managing director of W. R. Sykes' Interlocking Signal Co., died on the 12th ultimo, at Swanley, after a short and painful illness. The railway world in general and signalling circles in particular have lost a member who was highly esteemed.

*

Rapid-acting Vacuum Brake Trials near Vienna.

DETAILED particulars are just to hand of some further trials of the Rapid Acting Vacuum Brake on long goods trains. In our June issue we illustrated the details of the brake used. The previous highly successful trials to which we have referred were made with trains of 75 vehicles, and were more in the nature of private trials carried out by the Austrian State Railway Administration with the co-operation of the Vacuum Brake Co., and Messrs. Hardy Bros., the inventors and manufacturers in Vienna of the vacuum brake, but the trials on the 24-26 June last were made with trains of 100 vehicles and were attended by a large and distinguished gathering of Austrian military officers, military attaches, and railway engineers from all parts of Europe. The trials took place on the Ziersdorf-Absdorf and Absdorf-Hadersdorf sections of the Austrian State Railways. Applications, both service and emergency, were made at speed, and there were five observation points on the train but only in four instances were "jerks" recorded, and only in one an "oscillation"; all the other observations were "smooth."

We may add that the complete and elaborate records of the former trials have been translated and issued by the Vacuum Brake Co., and should be very useful.

*

Railway Shareholders' Association.

WE have received the official report of the first Railway Shareholders' Conference, held on the 8th ultimo. It may be obtained at the offices of the Association, 20 Copthall Avenue, E.C. Price 6*d*. It contains much that is worth reading and to which we shall refer on a future occasion.

*

Economising Engine Oil.

So far as we can see the Railway Shareholders' Association is a kind of *omnium gatherum* of amateur critics of our railway management and would-be railway directors. But at the late Conference Mr. R. Bell, M.P., made statements which certainly ought to be explained or contradicted by the chairman of the railway referred to. Mr. Bell says that one railway has recently appointed an "oil inspector," and that this official, to justify his appointment has "taken two pints [of oil] off each of a certain number of engines," with the result that nearly all these engines have had to be taken off their trains before reaching their destinations and sent to the shops. He further says that an express engine costs £3,000, and this is risked for 3*d*. worth of oil, and the engine is damaged to the extent of hundreds of pounds. He knows of five express engines that were taken off in succession for this reason. Mr. Bell also made a lot of other less vague statements of a similar nature and which he said

he could prove, but until he indicates the railway they cannot be enquired into. The use Mr. Bell proposes to make of the Association is evident.

*

Useful Diagrams for Railway Engineers and Others.

We have made arrangements to publish five diagrams by Mr. J. D. Twinberrow, Assoc.M.Inst.C.E., M.I.Mech.E., which will be of great service to draughtsmen, designers of rolling stock and other engineers. The diagrams have been prepared to facilitate the correct solution to problems of frequent recurrence, which otherwise can only be attained by more or elss tedious calculation. The results are plotted in the form of curves on squared paper, but the scales of the ordinates and of the abscissae are arranged to develop the curves in the form of straight lines radiating from a common origin at different angles; this ensures accuracy in the plotting and great ease in reading off the required results. The diagrams are as follows:—

Versed Sines of Chords of Curves.—The distance between the chord and the arc of curvature, or the throw-over of headstocks and the draw-in of the centres of long vehicles, are read off for lengths up to 80ft. and on curves up to 3,500ft. radius.

Proportions of Laminated Springs.—The number, width and thickness of plates to carry any given load on any length of spring, together with the resulting deflection, are read off to suit either locomotive, carriage or wagon practice.

Proportions of Helical Springs.—The size of round or of square spring steel required to carry any given load with any radius of coil, together with the resulting deflection, is read off. Separate diagrams are given for springs made from light wire and from heavy bar steel respectively.

Proportions of Axles with Outside Journals.—The correct diameter at any point in the length of the axle to suit any given load is readily ascertained. The length and diameter of journal and the width of bearing to suit the load is also given. The results may be read either for express passenger or for ordinary goods train working.

Proportions of Axles with Inside Journals.—Similar particulars to the foregoing are here ascertained to suit the condition of carrying axles with the journals arranged on the inner side of the wheel bosses.

*

Prevention of Corrosion of Iron and Steel.

In the transept of the Palace of Machinery at the Franco-British Exhibition, in the centre of the Shipping Section, Messrs. Wailes, Dove and Co., Ltd., Newcastle-on-Tyne, are showing their well-known patent "Bitumastic" enamels, coverings and solution, for the prevention of corrosion in iron and steel, and the protection and preservation of wood. On their stand, No. 337, is shown a model of a midship's section of a vessel, also a model workshop with smoke stacks, etc., all coated with their different "Bitumastic" specialities. These are all well worth the careful examination of all who are interested in the important question of corrosion, more especially as the firm claim that "Bitumastic" holds the world's record as an anti-corrosive protector.

Wailes, Dove and Co. devote themselves entirely to the manufacture of "Bitumastic," which has been used on the largest liners afloat like the "Mauretania" and "Lusitania," and is equally suitable for the protection of all valuable structures and plant on land, such as Bridges, Water Tanks, Pithead Gear, Refrigerating Plant, Roofs of Buildings, etc. It is interesting in this connection to note that at Genoa in 1905, Milan 1906, Savona 1906, and Bordeaux 1907, Wailes, Dove and Co. were awarded Gold Medals and First Class Diplomas of Merit.

*

Kearney's High-speed Railway.

We recently had an opportunity of seeing a model of the Kearney High-Speed Electric Railway. The track was about 200ft. long. The cars run on a single rail. There is also a guide rail above the car, so that derailment would be impossible unless something gave way. The centre of gravity is kept low by building the motors in the wheels. Vast economies are claimed for the system. Tube railways would be built like "switchbacks," with the stations close to the surface, lifts being unnecessary. The line would dive at 1 in 7 to a depth of about 100ft., and rise again to the next station. The tubes would be single except at the stations where the trains would pass. The proposed speed is 50 miles an hour. For surface railways the rails would be carried on steel T frames, double lines being used and speeds of 120 miles an hour obtained. Mr. Kearney hopes to get his system adopted on the North-West London tube, and states that were this done the line could be built for £120,000. We have mentioned the salient features of the system, and the main points of the model, which, of course, suffers from the disadvantages which are inseparable from all small models of rolling stock. Further particulars may be obtained of the Secretary of the Co., 17, Old Queen Street, Westminster, S.W.

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China-Clay.

Mr. Justice Eve has decided that China Clay is a mineral within the meaning of sec. 77 of the Railway Clauses Consolidation Act, 1845.

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Notice of Removal.

Messrs. C. A. Peters, Ltd., of Derby, manufacturers of "Carbolineum Avenarius" and other preservative compositions, notify us that they have removed their London Offices to 116, Newgate Street, E.C.

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Furness Railway.

In connection with their exhibit at the Franco-British the Furness R. Co. have issued the programme of their circular tours through English Lake-land. The programme is artistically prepared, 20 circular tours being illustrated.

Siegwart's Machine for Making Reinforced Concrete, Poles, Pipes, Piles, &c.

Constructional members of reinforced concrete have hitherto generally been solid and such things as piles formed in externals moulds. It naturally follows that in the process of making the reinforcing bars may get displaced and subjecting the concrete to pressure may distort them, and such distortion might seriously affect the strength of the member when subsequently the working load comes on it.

With the object of doing away with these troubles and facilitating the making of tubular reinforced concrete a Steel and Concrete Weaving Machine has been invented by Mr. Siegwart and was shown at work at Messrs. Cubitt's Works in the Gray's Inn Road, W.C., on the 27th ult.

In Mr. Siegwart's process no external mould is used, but the reinforcing bars are laid externally along an internal hollow core and the concrete is wound helically round the core thus keeping the bars exactly in the desired positions. Immediately after the concrete is so woven wires are also wound spirally round the outside of the longitudinal rods and embedded in the concrete, which is uniformily compressed by weighted rollers to an extent impossible by hand ramming, thus rendering the whole mass dense, compact and homogeneous. A coil of webbing is wrapped round the concrete to keep it in place until it is set. The core, which is collapsible, may be removed after 12 hours and the webbing after 3 to 4 days. By this process hollow articles of reinforced concrete are made of any length or thickness with absolute precision for the following purposes:—

Poles of all sizes and descriptions for telegraphs, telephones and tramways, power transmission and electric lighting standards, lamp-posts, railway signals, ventilating shafts and possibly ships' masts. Pipes of all descriptions for sewers, oil pipe lines, gas mains and water mains. Tubular members for constructional work, such as bridges, piers, or columns for buildings. Piles, either tapering or cylindrical.

A very fine aggregate of 1 to 3 in a particularly dry state is used.

The lengths of all these articles are only limited by that of the core; up to the present 45 feet is the longest pole made in one piece, and it will probably be found that when longer poles are required it will be more economical to make them in two lengths joined together, as the difficulties of transport grow with increased length. The diameter is only limited by considerations of weight. Some high pressure pipes, 24ins. diameter, designed to stand 180lb. pressure per square inch, will shortly be officially tested. High pressure pipes can either be lined with some bituminous composition, or the cement used in the concrete first mixed with "Medusa," which is found very effective in rendering concrete impermeable.

Some of the advantages claimed for this new form of manufacture are:—

Economy on material, because any given factor of safety can be accurately provided for, and the quantity of concrete and reinforcement exactly proportioned to the requirement, consequently there is no waste of material; on labour, as the machine requires only one skilled attendant, and the other labour is unskilled and employed mostly in handling material or moving manufactured articles. Consequently the cost of production is very low—less than half that of tubular or lattice poles.

Indestructibility.—The material is practically indestructible —for underground work it actually improves with age, whilst iron rusts and wood rots. Above ground no painting is necessary, and it is proof against white ants, teredo worms, and other destroying agencies.

Mobility.—The machine is semi-portable, and where large works are planned it can be erected near a sand deposit or fixed on a large barge.

Further particulars may be had from Messrs. Siegwart, Ltd., 1, Great Chapel Street, Westminster, S.W.

The Franco-British Exhibition.

This exhibition as a popular show is great; as a pleasure garden for fêtes it is greater, for nothing so good in the way of illuminations has ever been seen before; but in the proportion of "side shows" and other ingenious devices for extracting extra payments it is most probably the greatest exhibition ever held. In this last respect we think the line should have been drawn somewhere, because to permit an extra charge of 6*d*. for viewing an ordinary commercial process like glass making is preposterous.

The exhibition is now about as complete as it is likely to be, and so far as railway appliances are concerned it is anything but great—in fact, it contains the poorest display ever got together—and when one calls to mind the magnificent collections of rolling stock and other railway appliances that were shown at Paris, Liege and Milan, that at the Franco-British is positively depressing to contemplate. Apparently railway companies could not afford to do more than provide space for the wants of their publicity departments. The ghastly prices demanded for the pitches no doubt account for the large vacant spaces in the transept of the Machinery Palace, and which make the railway stands somewhat like oases. And as now arranged the shows are distinctly out of place.

There are, however, some exceptions. The best railway exhibit, from our point of view, is that of the South Eastern and Chatham R. Co., and which we have dealt more fully with on subsequent pages. The London and North Western and the Caledonian Cos. have jointly the best and most central position, and their exhibit is undoubtedly the most popular and is in all ways excellent. The most effective item is a model of a station with a passenger train and a long goods train, which continually performs shunting operations. All the movements of the trains and signals are governed from the signal-box, and are, of course, made by the agency of electricity. The model was made by Bassett-Lowke and Co., of Northampton, and it is correct in every detail, nearly every type of vehicle in use on the North Western system being represented, besides engines of the "Experiment" and 8-coupled goods classes. Large models of the King's saloon and also of the old coach "Experience," two or three smaller working models of locomotives, a quarter size locking frame on the "Crewe" (all-electric) system and models of the "Hibernia" and "Rathmore" are also shown, besides sections of old and present permanent-way. Large framed views of "beauty spots" and picture post cards, as well as the beautiful guide booklets (which the North Western do so well), are much in evidence, but they are not the staple of the show. Not the least interesting item are several original letters of George Stephenson, printed copies of which, in English and French, are given away, and form an interesting souvenir.

The *C. de f. du Nord* show two small power locking frames, one on the Bianchi-Servettaz system and the other on the new M.D.M. system; also some full-sized signals, block instruments, a ticket printing and issuing machine, and, with the help of a set of full-sized London and North Western points, a contact block for a cab-signal. There are also some North Western signals on this stand, so that the English and French patterns may be compared.

The Metropolitan R. Co. show an old carriage converted into a motor carriage for electric traction. The object of exhibiting this conversion is, we presume, to show how much money might have been saved if the old steam stock had been utilized instead of being sold at little better than scrap prices and new bought in its place. The ways of "electrifiers" are generally curious and always costly.

There are several other exhibits by railway companies, but they are all much alike—a back ground of framed "beauty spots," an occasional model of an engine or cross-channel steamboat, and a counter for post cards, adventitious literature and handbills. Of these shows, that of the North Eastern R. appears to cover the largest area—like the big drum in a band. Its *pièce de résistance,* a painting of an express train in full blast, should be raised to the top of the screen; it requires distance.

In the quadrangle of the "Palace of Machinery" the Canadian Pacific and Grand Trunk Cos. have each a kiosk, externally very ornamental, but inside there is not much but guide pamphlets and such like literature.

Knowing as we do what the private builders of rolling stock in this country could have shown had they seen their way to do so, it is much to be regretted that they are all conspicuous by their absence. The firm which boasts—quite truly—that it is the largest locomotive building concern in Europe contents itself with showing a large model.

Only one branch of mechanical engineering is fully represented and that is heavy steel making, magnificent displays being made by Vickers, Sons and Maxim, Ltd., Wm. Beadmore and Co., Ltd., and most of the other large firms. At these stands "component parts" of locomotives and other machines, guns, armour and boiler plates may be seen in the rough, finished, and tested to destruction.

There is also a grand display of models of all kinds of ships on view.

In both the French and British aisles of the Palace of Machinery there are some good displays of machine tools, that of Alfred Herbert and Co., of Coventry, being by far the best. Their turret lathes, milling machines, chucks and other tools are of the latest designs, finest workmanship, and are representative of the best modern British practice.

Hethringtons and J. Buckton and Co. show heavier tools and some of the other firms show tools which are neither Franco or British.

Of all the machinery unconnected with railways, perhaps the finest and most interesting is in the kiosk of *The Daily Mail,* in which may be seen in operation all the machines used in the production of a daily paper; the entire process shown except the manufacture of the "Copy."

Notes on Locomotives.

In our last issue we mentioned the new mineral engines now being delivered to the North Eastern R. by outside firms. These engines are thoroughly representative of the modern British all-coupled six-wheeled engine, in which great boiler power is the desideratum.

The particular engines in question, having been designed for hauling trains of mineral wagons only, are not equipped with any automatic continuous brake, but have a steam brake acting on both engine and tender, with, of course, the hand brake in addition on the tender.

In general design they are the essence of simplicity. The cylinders are between the frames, and have plain slide valves placed between their barrels. These are actuated by direct-acting Stephenson link motion controlled by lever reversing gear. The boiler has a round topped firebox of the standard North Eastern type; the inside firebox is stayed to the shell by direct staybolts.

The principal dimensions are :—

Cylinders, 18½-in. by 26-in.
Diameter of wheels, 4-ft. 7½-in
Rigid wheel-base, 16-ft. 6-in.
Working pressure, 180-lbs. per sq. in.
Boiler, barrel diameter, 5-ft. 6-in. by 10-ft. 7-in. long.
Firebox, 7-ft. long.
Heating surface, tubes, 1,453 sq. ft.; firebox, 136 sq. ft.; total, 1,589 sq. ft.
Grate area, 20 sq. ft.
Weight in working order, 47 tons 3 cwts.
Tender, diameter of wheels, 3ft. 9¼in.
Tender, tank capacity, 3,100 gallons.
Tender, weight in working order, 36 tons 11 cwts.

The Highland R. has recently put into service a new and enlarged class of express passenger engines which are a considerable advance on the previous engines of the type for this line, although they are not comparable with the heavy six wheels coupled locomotives at work on the railway.

These new engines, like all Mr. Peter Drummond's designs for express passenger traffic, have inside cylinder, four coupled wheels, and a four-wheeled leading bogie, this latter being of the Adams or spring beam type. The valve gear is of the Stephenson variety acutating plain slide valves placed between the cylinders; reversing is by steam gear. The springs for the coupled axles are driving coils for trailing laminated. The boiler is of the round topped type, with the firebox stayed with groups of sling-stays.

The dimensions are :—

Cylinders, 18¼-in. by 26-in.
Wheels, coupled, diameter, 6-ft.
Wheels, bogie, diameter, 3-ft. 6-in.
Wheelbox, rigid, 9-ft.
Total, 22-ft. 3-in.
Working pressure, 180-lbs. per sq. in.
Boiler, barrel diameter, 5-ft. 3-in. by 10-ft. 6-in. long.
Firebox, 6-ft. 4-in. long.
Heating surface, tubes, 1,516 sq. ft.; firebox, 132 sq. ft.; total, 1,648 sq. ft.
Grate area, 20.3 sq. ft.
Weight in working order, 49 tons 8 cwts.
Tender, diameter of wheels,
Tender, tank capacity, 2,180 gallons.
Tender, weight in working order, 33 tons 8 cwts.

An experimental engine of great interest is now in course of trial on the Northern R. of France. It constitutes an entirely new design for this line. It is of the four-cylinder compound type, with four coupled wheels placed between two four-wheeled bogies, thus forming the 4-4-4 class of which only one other representative is to be found, and that on the Baden States R.

Apart from the matter of wheel arrangement, the chief feature of interest lies in the boiler, which is of the water-tube type at the firebox end. Here it consists of a top header or drum connected to bottom headers by vertical tubes. The headers are connected to the ordinary barrel near the dome by large external circulating pipes. When the engine has passed through the experimental stage, we hope to deal more fully with this design.

For some years past the railway authorities of Baden have prosecuted a very progressive policy in the matter of locomotives, until the position of the modern stock is in the front rank of Europe. We have mentioned above the 4-4-4 type express engines. This, however, has been supplemented by the "Pacific" or 4-6-2 type with four compound cylinders. Following the practice which seems to be a standard of the builders—J. Maffei—for passenger engines, the frames are of the American or bar pattern, the leading and trailing ends being slabs.

The cylinders are arranged in the "Central European" manner, namely the high pressure between the frames and the low pressure outside, but, unlike this type, the power is distributed over two axles, the leading being the high and the intermediate axle the low pressure driver. In order to clear the other details placed between the frames above the bogie, the high-pressure cylinders are rather steeply inclined, but the outside cylinders are horizontal. All four cylinders have piston valves, each pair of H.-P. and L.-P. valves being actuated by a single set of Walschaerts gear. The starting valves are placed on the low-pressure steam chests, and are actuated by the reversing shaft.

The boiler is of the round topped type, with a wide and sloping firebox, 7ft. 11in. wide. The barrel is 5ft. 8in. in diameter and 17ft. long between the tube plates. The centre line is 9ft. 4ins. above the rails. It is fitted with the Schmidt super-heater.

The dimensions are :—

Cylinders, H.P., 16⅝-in. by 24-in.
Cylinders, L.P., 25⅝-in. by 26-⅜-in.
Wheels, coupled, diameter, 5-ft. 10⅞-in.
Wheels, bogie, 4-ft.
Wheels, radial, 3-ft. 3⅜-in.
Wheel-base, rigid, 12-ft. 11-in.
Wheel-base, bogie, 7-ft. 3-in.
Wheel-base, total, 37-ft.
Heating surface, tubes, 2,088 sq. ft.; firebox, 158 sq. ft.; superheater, 538 sq. ft.; total, 2,784 sq. ft.
Grate area, 48 sq. ft.
Weight in working order, 89.8 tons.
Weight on coupled wheels, 50.4 tons.

Another interesting class of locomotive in which full use is made of the advantages to be derived from high super-heat has now been adopted as the standard goods tank engine for the Prussian State R. The design is one which is unknown at present on British lines, being ten-wheeled and all-coupled. To reduce the resulting stiffness the first, third and fifth axles have 1in. side play.

The fourth axle is the driving which would ordinarily result in a very long connecting rod, but this is overcome by extending the piston rods so that the slide bars are in the rear of the first coupled wheels, and to reinforce the piston rods they are provided with intermediate crossheads working on prolongations of the ordinary guide bars.

The tank capacity is large, being 2,520 gallons carried in side tanks, but the economy in water claimed for super-heating will, of course, render this equal to a considerably larger quantity.

The cylinders are of abnormal size, but this again is the outcome of the high super-heat; in fact, their dimensions, coupled with the low boiler pressure carried, only 170lbs., is an object-lesson in locomotive proportions, provided always there are no serious off-sets which will arise, or which are not made public. The following are the leading dimensions :—

Cylinders, 24-in. by 26-in.
Wheels, diameter, 4-ft. 5.2-in.
Heating surface, tubes, 1,332 sq. ft.; firebox, 120 sq. ft.; superheater, 458 sq. ft.; total, 1,910 sq. ft.
Grate area, 24.2 sq. ft.
Working pressure, 170-lbs.
Weight in working order, 72.6 tons.

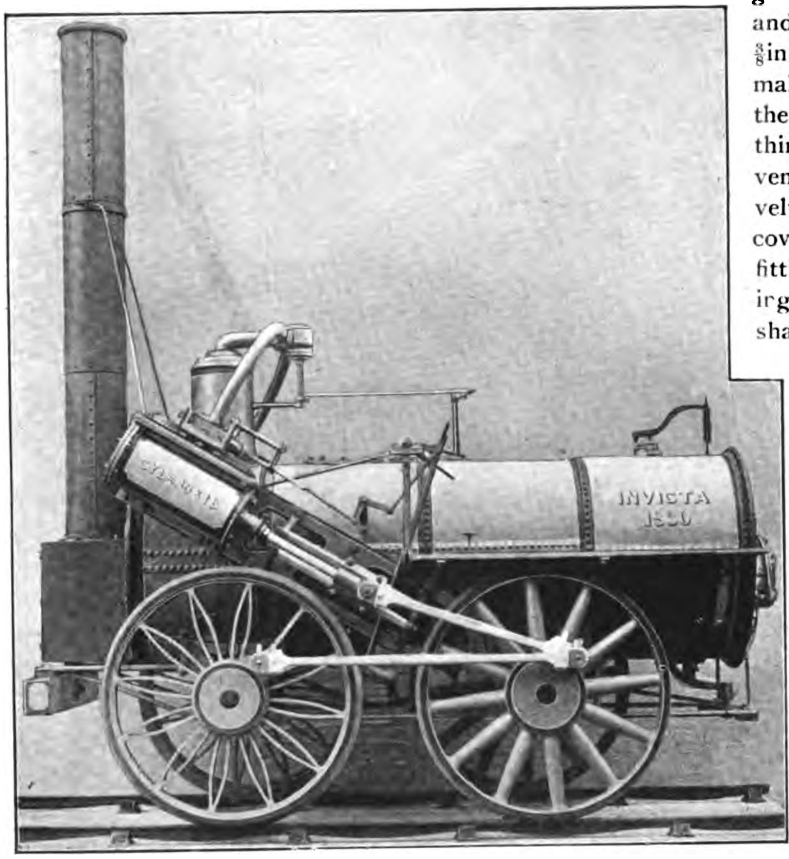
The cylinders are fitted with piston valves, actuated by Walschaerts valve gear.

South Eastern and Chatham Railway Co.'s Exhibit at the Franco-British Exhibition.

THE fine examples of full-sized rolling stock sent to the Franco-British Exhibition by the South Eastern and Chatham R. Co. are highly creditable, and are thrown into the prominence they deserve by the fact that, with one unimportant exception, they are the only ones in the Exhibition: the other railway shows are, excepting those of the London and North Western R. and the *Chemin de fer du Nord*, of no particular interest.

Three principal items are shown by the S. E. and C. R. Co., viz.:—an express engine, a tri-composite carriage and the "Invicta."

The engine is one of the 4-4-0 class, designed by Mr. H. S. Wainwright, M.Inst.C.E., about two years ago, and which has been very successful in work, is well suited for the traffic of the railway. The engine, of which a view is given on page 248, is highly finished, and stands on a length of standard permanent-way provided with a Sykes locking bar. Its principal dimensions are given under the



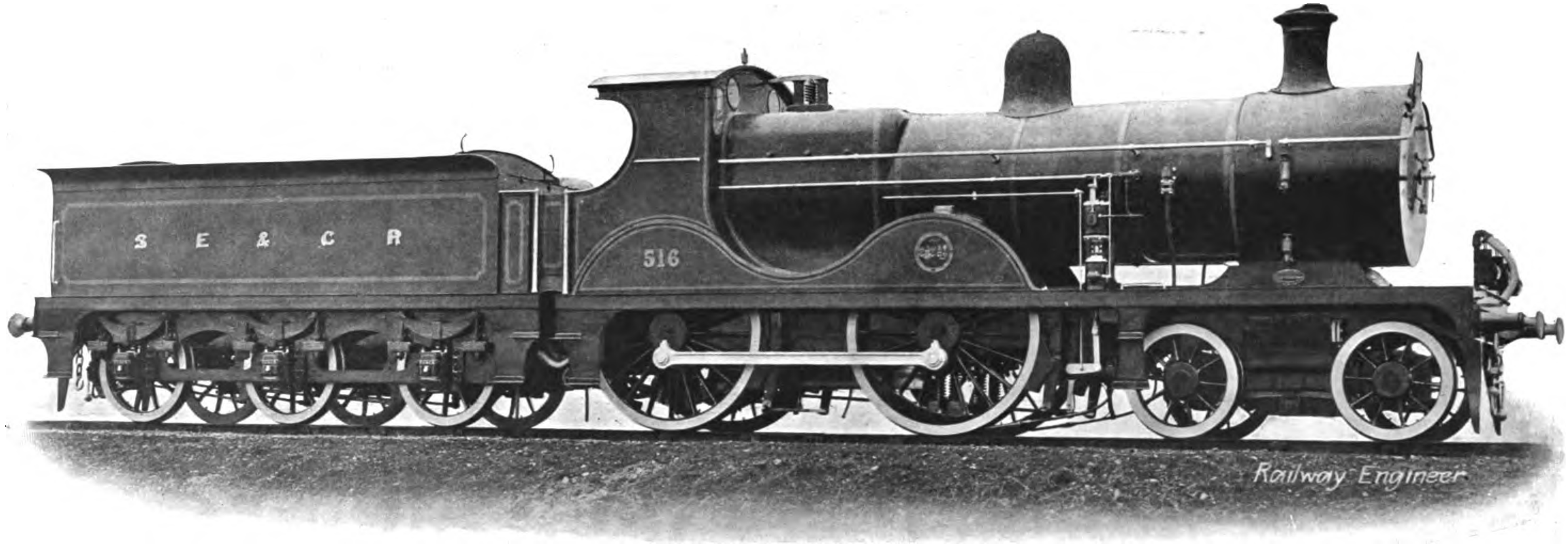
The "Invicta."

illustration, but we may add that it is fitted with Stephenson link motions and steam reversing gear, cambered boiler tubes of Nicro copper $1\frac{7}{8}$in. diam., Hodge and Spencer's auxiliary bearing springs, an extended smoke-box containing Stone and Co.'s patent regulating blast pipe, ash ejector and louvre spark arrester, steam sanding apparatus, fittings for steam heating the train and the vacuum automatic brake.

The carriage is one of the corridor tri-composites used for the through services between Dover, Folkestone, and other South Coast watering-places and Liverpool, Manchester and other towns in the north served by the North Western, Great Western, and Midland systems. It has a guard's and luggage compartment and two lavatories. It was also designed by Mr. H. S. Wainwright, and is illustrated, accompanied by its chief dimensions, on page 248. It is beautifully finished and furnished, and in every way equal to the rolling stock of the northern systems on which it runs. Its width is governed by the loading gauge of the S. E. and C. system. It seats four first-class, six second-class and twelve third-class passengers. The compartments are roomy, as is necessary for long through journeys, and each has two of Turton Platt's "Eros" roof ventilators with regulating grids. The carriage is fitted with Stone and Co.'s system of electric light—each of the first and second class compartments have two 12 c.p. lamps and each of the third class two of 8 c.p. The heating is by steam with Laycock's storage heaters. The body framing is of teak and the panels and facias of mahogany. The interior of the first-class compartment is framed with American walnut with mahogany mouldings relieved with gold, the seats, etc., are covered with "Tashmere" tapestry and the floor is covered with an Axminster rug on "Kork" $\frac{3}{8}$in. thick. The second-class compartment is panelled in mahogany and upholstered with "Tashmere" velvet, and the floor covered with a Brussels rug over "Kork." The third class is framed in teak, filled with match-boarding veneered bird's-eye maple, and upholstered with "Railway" velvet, the floor being laid with bordered "Suberium" covering. The lavatories have Jas. Beresford and Son's fittings, and are panelled with "Emdeca." The under framing and bogie framing are of steel, but in a future issue we shall describe this more in detail. Between the bodies and the underframe are A. G. Spencer's body cushions. The buffing springs are Spencer's indiarubber cylinders in two series at each end on the centre line of the underframe. The connection to the corner buffers is by an equalizing beam pivoted to the central buffer plunger. The corner buffer springs are A. G. Spencer's patent double buffer arrangement with concentric rubber springs arranged to give a high final resistance.

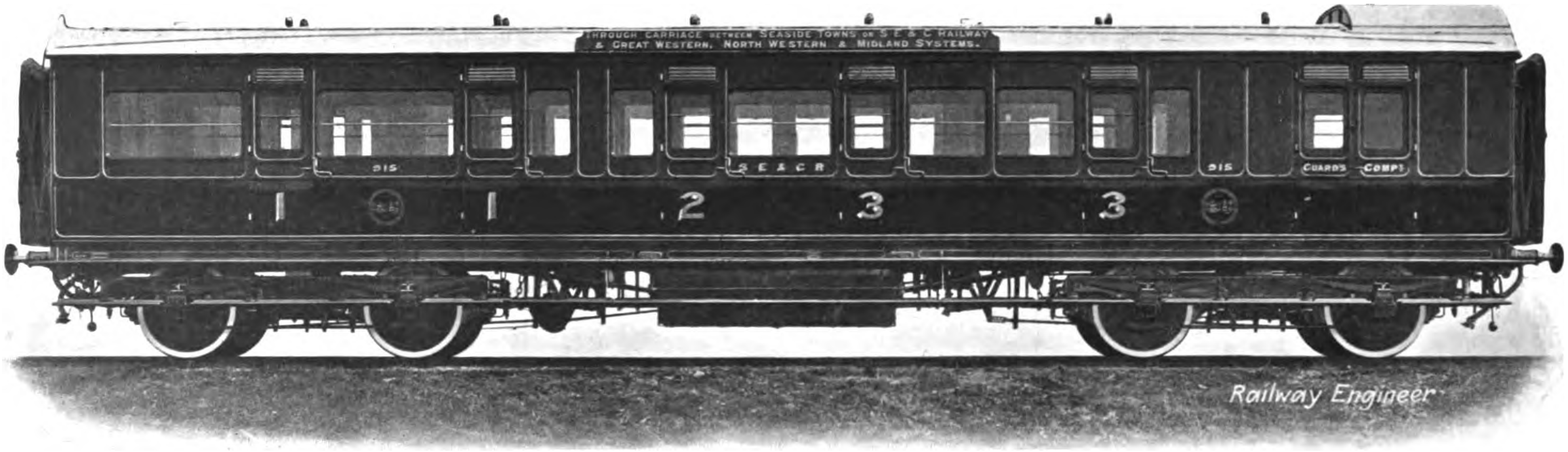
The old "Invicta" is most interesting, and when compared with the modern engine above described, and which is next to it, shows at a glance the progress made by the steam locomotive since the time of George Stephenson, who designed the "Invicta," and which, according to *The Development of the Locomotive*, by Mr. Clement E. Stretton, of Leicester—the "Invicta" being the company's only locomotive—worked the opening train of the Canterbury and Whitstable R. on May 3rd, 1830. It was built by Robert Stephenson and Co., and had cylinders 10in. by 18in., wheels 4ft. diam., boiler barrel 3ft. 4in. by 8ft., working pressure 40lbs. per sq. in., wheelbase 4ft. 7in. The boiler contained 25 tubes 3in. diam. Its weight was between five and six tons, and originally it had a somewhat shorter boiler than the present one.

All our illustrations have been made from photographs kindly placed at our disposal by Mr. H. S. Wainwright, the chief mechanical engineer of the South Eastern and Chatham R. Co., who it is to be hoped will reap the reward of their enterprise in sending such a fine display to the Franco-British Exhibition.



4-4-0 EXPRESS PASSENGER ENGINE, SOUTH-EASTERN & CHATHAM RAILWAY.

Cylinders, 19½ in. by 26 in.; coupled wheels, 6 ft. 6 in. diam; fixed wheelbase, 20 ft. 4 in.; heating surface, 1,532 sq. ft.; grate area, 21·15 sq. ft.; boiler pressure, 180 lbs. per sq. in.; weight in working order, on the bogie 17 tons 7 cwt., on the driving wheels 17 tons 12 cwt, on the trailing wheels 17 tons 6 cwt.; total, 52 tons 5 cwt.; total weight of engine and tender, 91 tons 7 cwt.; total length over buffers, 55 ft. 1½ in.



TRI-COMPOSITE CORRIDOR CARRIAGE WITH GUARD'S AND LUGGAGE COMPARTMENT AND TWO LAVATORIES. S. E. & C. R.

Length over buffers, 53 ft. 10 in.; between centres of bogies, 33 ft. 6 in.; wheel base of bogies, 8 ft.; length of body, 50 ft. 1 in.; width at waist, 8 ft. 0¾ in.; height from rail to roof, 11 ft. 8½ in.

Both constructed at the Company's works at Ashford to the designs of Mr. Harry S. Wainwright, M. Inst. C.E., Chief Mechanical Engineer, and exhibited at the Franco-British Exhibition.

Notes on the Erection of Bridges.—XI.*

It may perhaps not be possible to conclude this series of articles in a better way than by some description of the manner of erection of the bridges that have been built across the Niagara river to carry rails and roads between the United States and Canada.

Some reference was made to one bridge across the Falls in Article IX. (March, 1908, page 80). This was of the old-fashioned suspension type, a truss being carried between the points of support to stiffen the bridge and prevent the inevitable undulations that must otherwise occur under heavy railway traffic.

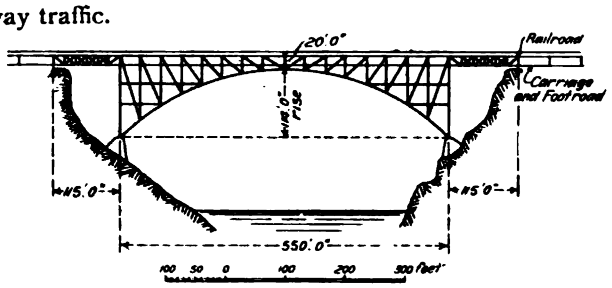


Fig. 35.

The new bridge (see fig. 35) at this point of the Falls is of the steel arch type of 550ft. span and 114ft. rise, provision being made for a roadway at the lower level and for a double line of rails over this.

The principal difficulty that had to be met in this case was the continuance of the traffic both on the roadway and also on the railway above the road, and the result was said to be that not one train was delayed on account of the reconstruction, and no hindrance was experienced in the road traffic except for a period of a couple of hours on each day that the upper floor was being placed in position, the object of the stoppage being to protect the road traffic from falling material, and the time chosen being that of the least railway traffic overhead.

Other difficulties that ensued were the variable deflection of the old suspension bridge under travelling loads, and the small amount that was available as clearance between the old work and the new.

The two halves of the arch were built out from the abutments on each side as cantilevers, which were anchored back to the solid rock at each side, the attachment being made at the upper part of the end post, and the material in the side spans being (see fig. 35) used for anchor chains in the shape of eye bars.

An adjusting toggle was used at this point (see fig. 36) which by means of right and left-hand screws worked by 19 men with capstan bars at each screw was found capable of lifting or lowering the cantilever erection in either direction as required. The rear end of the adjusting toggle was anchored firmly down into a hole blasted out of the rock, the hole being filled in with concrete.

It was originally proposed to convey the material out to its place in each cantilever by means of a wire rope cable apparatus to be suspended from the two towers of the old suspension bridge, but this was ultimately abandoned in favour of a pair of light travellers, one on each cantilever, by means of which the two halves of the arch were built out simultaneously but independently of each other until they met in the centre of the bridge. Each of the two travellers was provided with two engines placed in the towers of the old bridge, to work the lifting of material to its place in the structure. The heaviest weight handled by the travellers in this way was 32 tons.

When the two end spans had been erected the travellers were erected upon them in order to lift the skewbacks of the arch into position, and this done the commencing panels of the arch were erected by means of a light scaffolding, which was, however, only used until the first panel was erected and tied back to the anchorages. After the first panel was thus erected the travellers were brought forward to their work, and the correct position of the end posts were given by the use of the adjusting toggle, ready for the erection of the second panel.

A railway track for the conveyance of the material was provided on each side of the bridge, the rails being continued over the bridge as the erection progressed by means of the brackets intended ultimately to carry the side walks.

In this way the erection of the cantilevers was carried out until the two halves met in the centre to complete the arch, the lower floor and lateral bracing being put in as the work progressed. The level of the new floor and bracing was also purposely left low in order that it should not be touched by the deflection of the old bridge under moving loads, and thus producing additional loads on the anchorages.

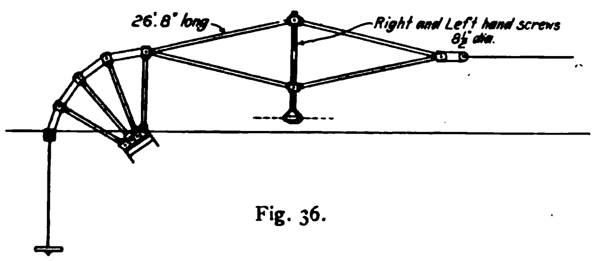


Fig. 36.

The central panels of the arch were not finished in the shops until six panels from the abutments had been completed on each side, leaving a central measurement of a little over 134ft., which, however, on account of weather conditions could not be so accurately determined as was desirable.

When both sides had been completed it was found that there was an opening of 8ins. between the two halves of the arch rib, which, however, it was anticipated would be accounted for when the adjusting toggles were loosened on each side.

It was expected that the compression that must occur when the two halves of the top chord met together and the consequent release of the tension stresses would shorten the members to their proper lengths, but it was found that the ribs of the arch met first and took the compression stress, so that in fact there was an opening left of ¾in. in the top chord at the centre, whilst they were yet in tension.

It therefore became necessary to force the two halves of the top chord apart at the centre, which was done by means of a compression toggle, and by this means an opening of 1in. was made and a wedge inserted. At this point in the erection the exact camber was measured and found to agree with that actually required, and the lower floor and bracing was thereupon raised to its required level.

The stiffening trusses of the old bridge were then blocked up from the new work and the cables removed, and this en-

* The previous articles of this series appeared in the *Railway Engineer* of the following dates:—I., December, 1905; II., November, 1906; III., April, 1907; IV., June, 1907; V., August, 1907; VI., October, 1907; VII., November, 1907; VIII., January, 1908; IX., March, 1908; X., May, 1908.

abled the new upper floor to be erected in place, the old upper floor and top chords being at the same time removed. This part of the work being done between trains, two panels at a time, the time occupied in the work being about two hours each day.

The work was begun in April, 1896, and was completed in August, 1897.

The Niagara cantilever bridge was the first structure of its kind erected in the United States, and carries the double track of the Michigan Central Railroad over the gorge of the Niagara river. It was erected in 1883.

The position is about two miles below the Falls and about 300ft. above the replaced railway suspension bridge described in Article IX. and above. The height of the bridge is 265ft. above the water, which at this point travels over 16 miles per hour, and is one torrent of whirlpools and eddies, the depth of water being estimated at from 50 to 80ft.

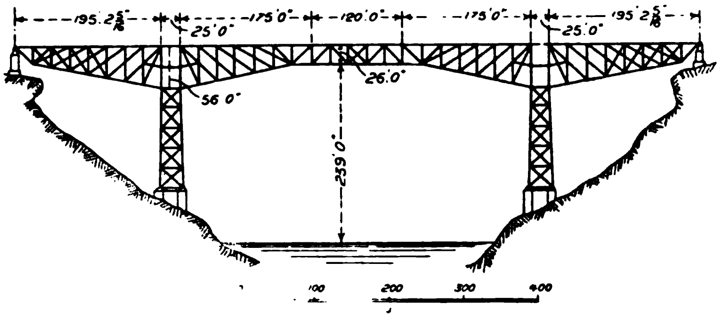


Fig. 37.

The span of the bridge between the bluffs is 850ft. (fig. 37) and the design consists of two double cantilever arms carrying a suspended span in the centre of the opening. The distance between the centres of the supporting piers is 910ft. 2¼ins., each cantilever being 395ft. 2$\frac{5}{16}$ins. in length, the suspended span having a length of 119ft. 9⅞ins., the two parallel trusses being 28ft. apart.

On each side of the central opening and between the cliffs and the two piers, ordinary timber staging was used for the erection of these parts of the bridge, and the trusses were erected by means of derricks placed at the river ends of the staging. The materials were lowered from the cliffs by derricks on to the staging, where they were conveyed by hand cars to the river end derricks, to be lowered to their place in the structure.

When the towers were completed in this way additional staging was superposed and the shore spans of the cantilever were built upon these stagings, and immediately the shore arms were completed a track was laid upon them and the erection of the river lengths of the cantilever arms commenced.

A traveller (see fig. 38) composed of a timber framework braced by iron rods was placed upon the rail tracks and run out towards the river upon cast-iron wheels 14ins. diameter, 8ins. face, on steel axles, and running between timber guides. It was anchored down to the completed shore arm of the cantilever. The total length of the traveller was 66ft. 6ins., and the end projected out 40ft. beyond the completed work, an extension being provided at the rear. The width of the traveller was 38ft. 6ins. and the height 21ft., and two derricks were provided for handling the material, power being provided by means of a hoisting engine and vertical boiler. The derricks lifted the material from the hand cars and either swung round and deposited the work in its place or handled it so that it could be lifted from a cross beam placed upon the traveller.

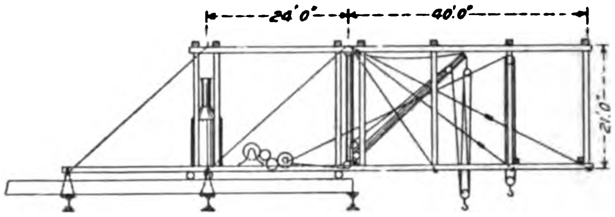


Fig. 38.

As each panel of the cantilever structure was built up in this way the traveller was moved forward to take up new work and at the same time a hanging platform for the workmen was hauled forward, being suspended from the traveller as it moved along the structure. The maximum weight handled by the traveller was a little over 5 tons.

The central independent span was erected in the same way by means of the travellers, the bottom chord being made so that it would resist compression as a continuation of the cantilever until the centre panel was reached. At this point the two travellers were only 40ft. apart, and the remainder of the work was done from timber beams laid on the top between the ends of the travellers, and thus the finishing connections were made. The travellers were then taken down and other staging removed, and then the permanent tracks were laid down, the whole erection of the bridge only occupying eight months.

The Niagara Falls and Clifton Bridge was built in 1895-8 to replace the old suspension bridge of 1,253ft. span, and carries a highway across the river two or three hundred yards below the Falls.

The bridge consists of one central span having braced steel arch ribs with two hinges and a span of 840ft. between the centres of the end pins, and outside this opening (see fig. 39) are two shore spans of 190ft. and 210ft. respectively. The height of the intrados is 150ft. above the bearing pins and 170ft. above the water, which at this point is estimated to be about 175ft. in depth.

The sides of the gorge are solid rock, so that the situation is an ideal one for this type of construction.

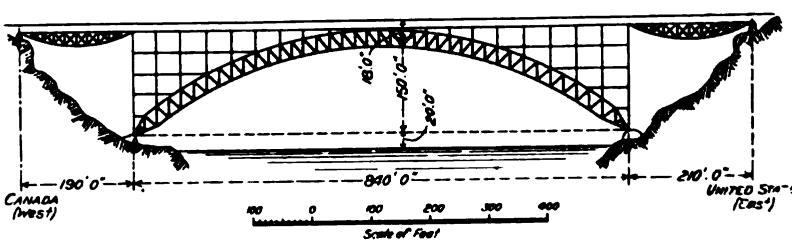


Fig. 39.

The old suspension bridge consisted of two steel stiffening trusses 12ft. deep., spaced 17ft. 6ins. centre to centre, suspended from wire cables 6ins. diameter resting on steel towers on each bank rising 100ft. in height, the cables being carried back to anchorages 250ft. away on each side, the suspension from the cables being effected by means of ⅞in. wire ropes spread 5ft. apart.

It is said that the old structure was very sensitive to wind and also to loads passing over the bridge, so much so that the

deck movements during a strong wind were similar to those of a ship at sea in a gale of wind, and that a comparatively small load entering the bridge at one end would perceptibly lift the structure at the other end, also that the difference in temperature between night and day would raise the floor of the bridge nearly one foot at the centre of the span.

At the commencement of the erection of the new structure reception yards for the new material were provided at each end of the old bridge; the material, however, was all brought to the site on the American side on account of the greater railway facilities on that bank of the gorge.

At the same time a narrow gauge railway was laid down on one side of the existing suspension bridge, sufficient room being left alongside this track for the ordinary highway traffic over the old bridge. The material for the new structure was run out by this means on hand cars to the Canadian side, or partly across, as required.

On each side of the gorge travellers were provided, being made to run along upon the top chord of the stiffening truss of the old bridge. Two eight-spool hoisting engines were provided at each end, and ropes from these to the moving travellers worked also along the top chord.

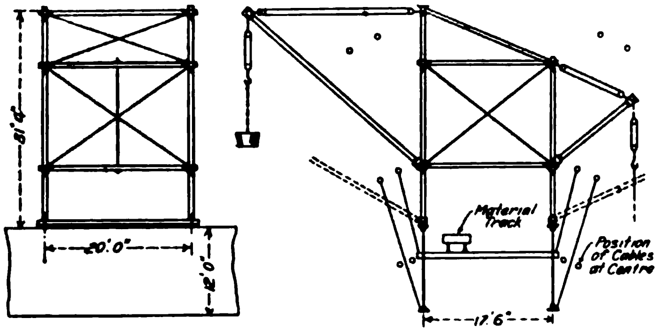


Fig. 40.

The suspension cables of the old bridge were much in the way of the lifting booms of the travellers (see fig. 40), but by an ingenious arrangement the booms were made short and long, and arranged so that they could work sometimes under and at other times over the cables, which, of course, could not be removed. The travellers were lightly built on account of the small comparative strength of the old bridge, the maximum weight they were allowed to carry being only 6 tons on one boom.

Another difficulty arose in that the old stiffening trusses of the old bridge came in the way of one arch rib of the new structure at a point some distance away from the centre of the span, and as it was necessary to maintain the efficiency of the old bridge throughout it was decided to cut away the lower part of one of the old stiffening trusses below the level of the floor for a length of about 160ft.

The old stiffening trusses were for this purpose strengthened at this point, and the highway was partly carried by new floor beams which were specially suspended from the main cables.

The shoes of the arch had each a weight of about 16 tons and were the heaviest weights to be lifted throughout the erection of the bridge. The travellers were not powerful enough to lift them, and as the material was all delivered upon the American side the shoes for the other or Canadian side were carried across the gorge by the Niagara railway arch, about two miles up the stream. They were landed on the top of the bank and then lowered to the bottom of the gorge by two sets of lines, one set working from the suspension cables near the towers and the other set working from the cable near the centre of the span.

The end panels of the arched ribs were erected on timber staging, and from this the remainder of the panels were built out panel by panel, anchorage rods being provided at each panel point until about seven-tenths of the half rib was erected as a cantilever. Each of the anchorage rods was provided with adjusting tackle so that it could be lengthened or shortened as required, the position of the panel points being carefully checked as the work proceeded, and as the site was peculiarly subject to high winds and mists, freezing at many times, this was a very precarious work.

When the building-out had proceeded to the $\frac{7}{10}$ stage the main anchorage ties were attached, and the previously-fixed anchorage rods were slackened so that the main anchorage would take all the stress.

Up to this point it was found very difficult to keep the growing structure sufficiently stable on account of the tilting over of the old suspension bridge upon which the travellers worked, and such were the conditions that it was found necessary to lower weights from both sides of the bridge simultaneously to avoid the twisting of the old stiffening trusses. Added to this difficulty was the trouble that when a load was swung out any distance by the traveller booms it was necessary to stiffen the side trusses from the platforms of the old bridge. Another difficulty consisted in the suspenders of the old bridge, which were only 5ft. apart, between which the lifting booms had to be interlaced, until the booms could work above the suspending rods.

It was intended, when the bridge was designed, that the two halves of the rib should be erected a little too high so that they could be lowered into place by means of the adjusting toggles on each bank, but this had to be modified during the operations for the reason that there was insufficient clearness between the old and new work, and also it was found that the top chord members of the arch would meet first. Another reason was the uncertainty of the correct distribution of the stresses had this been done, the stresses being so very different when the two halves of the arch were acting as cantilevers and the length of the members being modified in consequence.

This method of attempting the closure of the arch members was therefore abandoned, and the erection was carried out in such a way that the position of the booms would be normal and final when the temperature was at 60°. It was also arranged to provide a third hinge in the centre of the bottom chord so that this hinge should carry the stress arising from the dead load before the top chord was in position.

This was, however, modified when the top chords at this point were erected by forcing apart the two top members by means of a hydraulic ram, by which the correct stress was produced at the top panel point before the final closure was put in its place.

This required a very careful calculation of the movement of the central panel point of the rib whilst it was being carried by the top anchorages, the extension of the anchorage bars under the stress, the play in the connecting pins, and the distortion of the arch; and it was found that these considerations would cause the forward point of the arch to move forward 5ins. and deflect 14ins., and for this reason the toggles were therefore set 5ins. short.

The central hinge in the lower chord was formed by a

12ins. pin, which, although of temporary use, was allowed to remain in its place, being finished flush and covered with plates riveted on the outside of the webs of the chord, thus giving the appearance of a riveted joint.

The central upper joint opening was forced apart from 3¾ins. to 6ins. by the hydraulic rams exerting a thrust of about 165 tons at a temperature of 60°, and when the opening was thus enlarged it was filled with a cast-steel key made to fit the section of the upper chord, this being covered over on each side of the web by plates riveted on as in the case of the lower chord, the rivet holes for these plates, of course, being drilled on the ground to suit the case.

After the closure was completed the bars used for anchorage were removed, and the erection of the steel plate floor was begun, working from the centre towards both ends, all the material for the Canadian side having previously been hauled over from the American bank for the purpose.

At the central part of the opening it was necessary to provide two temporary moveable bridges for the traffic, the length of the temporary bridges being 45ft., a little longer than the distance of a floor panel length. These temporary bridges rested at one end upon the completed structure, and at the other end upon the old suspension bridge structure, and as they were several feet above the floor level inclined approaches were provided at each end. As the work of putting in the floor progressed the temporary bridge was drawn forward as each bay was completed.

To ensure the safety of the workmen engaged on the bridge, a boatman was kept constantly on the look-out on the water below, but fortunately his services were never required.

Upon the completion of the new bridge the old suspension cables were cut in the centre and wound up on reels. They were found to be in good condition and were re-used for another suspension bridge at Leicester, N.Y., where the gorge is narrower. The two halves of the cable were used, thus doubling the effective area of the cables for the less span.

Railways in India, 1907.

THE Annual Report of the Railway Board shows that:—

During the year 924 miles of line were opened to traffic, bringing the total mileage open, after allowing for abandonment and minor corrections of mileage, up to 30,010 miles of the following gauges:—15,821 of 5ft. 6in.; 12,613 of 3ft. 3⅜in.; 1,234 of 2ft. 6in.; 342 of 2ft.

There were 290 miles of line sanctioned during 1907, *viz.*:—255 of 3ft. 3⅜in. gauge; 35 of 2ft. 6in. gauge.

Up to the end of March, 1908, the mileages were—Lines open, 30,206; Lines under construction or sanctioned for construction, 2,516.

The actual capital outlay (excluding premia for the purchase of companies' lines) from the commencement, on all open lines and lines partly opened, amounted at the close of the calendar year 1907 to Rs. 39,843.15 lakhs, and that on lines wholly under construction to Rs. 242.35 lakhs. In addition Rs. 84.06 lakhs were incurred on miscellaneous items (English stores, etc.) connected with railways. The total outlay amounted to Rs. 40,169.56 lakhs. ...

All sanctions for expenditure are given with reference to the official year, and the sum of Rs. 1,500 lakhs (£10,000,000) has been provided for 1908-1909 divided as follows:—(*a*) For open lines, including Rs. 547¾ lakhs for rolling stock, Rs. 1,148.88; (*b*) for lines already under construction—(i.) begun prior to 1907-1908, Rs. 331.12; (ii.) begun during 1907-1908, —; (*c*) for lines to be begun in 1908-1909, Rs. 20.00; total Rs. 1,500.00 lakhs.

For the year 1907-1908 the Railway Board made a provision of Rs. 568 lakhs for rolling stock.

The additions made during 1907 to the rolling stock of the railways consisted of 229 engines, 736 coaches and 6,118 wagons, the numbers under supply being 514 engines, 1,879 coaches and 15,727 wagons. Subsequent to the 31st December, 1907, the provision of 89 engines, 406 coaches and 4,821 wagons has, in addition, been authorised; 283 engines, 1,260 coaches and 7,018 wagons were fitted with automatic brakes, bringing the total number so fitted at the close of the year up to 3,702 engines, 13,452 coaches, and 13,276 wagons, as against 2,572 engines, 6,047 coaches, and 110,463 wagons not fitted; 1,110 vehicles were fitted for gas and electricity, making the total number so fitted at the close of the year 12,849, as compared with 6,274 not fitted. The number fitted for gas was 10,677, and for electricity 2,172. Means of communication between passengers and guards and drivers are fitted to many fast trains, both State and Companies'. The Railway Board consider this matter to be one of great importance and are strongly pressing the more extended use of the appliance on all lines. 94 stations were fitted during the year with apparatus for interlocking points and signals, and 111 with automatic instruments for signalling trains between stations.

Statistical Results of Working.

With a net addition of 913 miles to the open mileage, the gross earnings of all Indian railways during the calendar year 1907 amounted in round figures to Rs. 4,726.87 lakhs, compared with Rs. 4,411.73 lakhs in 1906, an increase of Rs. 315.14 lakhs. Of the increase in the gross earnings, Rs. 227.85 lakhs were absorbed in additional working expenses. The net earnings amounted to Rs. 2,298.28 lakhs, against Rs. 2,210.99 lakhs in 1906, or an increase of Rs. 87.29 lakhs. These net earnings yielded a return on the capital outlay (Rs. 39,843.15 lakhs) on open lines and lines partly open of 5.77 per cent., as compared with 5.83 in 1906. Of the increase of Rs. 315.14 lakhs in the gross earnings, the North-Western State earned Rs. 92.77 lakhs, or 29 per cent., the Great Indian Peninsula Rs. 44.52 lakhs, or 14 per cent., and Bengal and North-Western Rs. 21.16 lakhs or 7 per cent., and the remainder was contributed principally by the Bengal-Nagpur, Eastern Bengal State, Oudh and Rohilkhand State and Southern Mahratta railways.

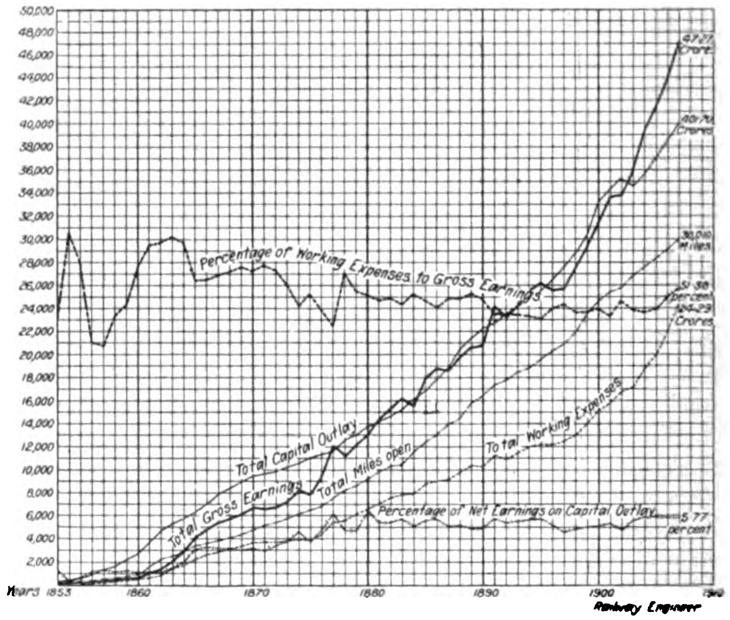


Diagram showing for each year the totals up to 31st December, 1907, for capital outlay, gross earnings, working expenses, and length in miles open, also percentage of net earnings on capital outlay and percentage of working expenses to gross earnings.

The figures on this scale represent lakhs for the capital outlay, tens of thousands for gross earnings and working expenses and miles for length open.

In the case of percentage of net earnings on capital outlay, and percentage of working expenses to gross earnings, each square represents one and two per cent. respectively.

The "total capital outlay" is that on all Indian railways, viz., (I.) open and partly open, (II.) on lines wholly under construction, and (III.) on miscellaneous items; while for the purposes of the "percentage of net earnings on capital outlay" (I.) alone is reckoned.

The decrease in the total capital outlay in 1903 is due to revision of the outlay hitherto adopted for lines purchased by the State from Guaranteed Railway Companies.

The development of passenger traffic, noticed in the last report, continued during the year under review, and a larger number of pilgrims, native marriage parties, visitors to fairs, etc., was carried by railway. The visit to India of H.M. the Amir of Kabul and the holding at Calcutta of an Industrial Exhibition also contributed to this development. The scarcity in the United Provinces and Behar also led to the movement of labourers in search of employment. The total number of passengers carried was 305.89 millions, against 271.06 millions, and the earnings therefrom amounted to Rs. 1,504.50 lakhs against Rs. 1,368.31 lakhs. The number of third-class passengers carried was more

by 31.86 millions and the earnings therefrom by Rs. 123.44 lakhs. The other classes also showed satisfactory increases. Of the increase of Rs. 136.19 lakhs in the passenger receipts, the North-Western State earned Rs. 28.74 lakhs, or 21 per cent., and the remainder was contributed principally by the East Indian, Great Indian Peninsula, Eastern Bengal State, Bengal and North-Western, South Indian, Rajputana-Malwa and Madras railways.

The average rate charged to passengers of all classes was 2.44 pies per mile, just over 1-5th of a penny, and the average distance travelled was about 39 miles. There have been no material fluctuations in these figures since 1884.

The aggregate tonnage of goods lifted during the year 1907 was 62.10 million tons, and the earnings therefrom were Rs. 2,924.26 lakhs, an improvement over the previous year of 3.23 million tons and Rs. 164.57 lakhs. Of the increase in the goods receipts the North-Western State earned Rs. 63.37 lakhs, or 39 per cent., the Great Indian Peninsula earned Rs. 31.01 lakhs, or 19 per cent., and the remainder was contributed principally by the Oudh and Rohilkhand State, Bengal-Nagpur, Bengal and North-Western and Southern Mahratta railways.

There was a decrease of Rs. 9.11 lakhs in the goods receipts of the East Indian, due to the reduction of coal rates and suspension of booking of goods traffic from 20th to 29th November, 1907, in consequence of a strike amongst the running staff of the line. The total weight of the traffic in "Grain and pulse," "Cotton, raw and manufactured," "Coal," "Oil seeds," "Sugar," "Salt," and "Jute" during the year 1907 amounted to 33.71 million tons, and the earnings therefrom to Rs. 1,915.48 lakhs, against 30.95 million tons and Rs. 1,777.04 lakhs respectively in the previous year. The traffic in these commodities amounted during the year 1907 to 70.73 per cent. in weight and 70.06 per cent. in earnings of the total traffic carried for the public, against 70.27 per cent. and 68.90 per cent. respectively in the previous year.

Coal.—During the year 1907 the total output from the collieries in India and Burma amounted to 11,150,000 tons, against 9,780,000 tons in 1906. The exports of Indian coal to Indian ports, principally from Calcutta to Bombay, Karachi and Madras, rose from 1,830,000 tons to 1,870,000 tons or by 34,000 tons, and those to ports outside India, including Burma, principally from Calcutta to Rangoon and Ceylon, fell from 1,394,730 tons to 1,040,240 tons, or by 354,490 tons. The imports of coal from the United Kingdom increased from 199,220 tons to 227,180 tons, or by 27,960 tons, and those from other countries from 27,150 tons to 74,410 tons, or by 47,260 tons. The total quantity of Indian coal consumed by Indian railways during the year 1907 increased from 2,880,000 tons to 3,340,000 tons, or by 465,000 tons, and the amount of foreign coal consumed from 37,280,000 tons to 54,860 tons. The traffic in coal carried by railways increased from 11,190,000 tons in 1906 to 12,190,000 tons in 1907, while the earnings therefrom fell from Rs. 322.83 lakhs to Rs. 318.55 lakhs. The decrease in the earnings with an increase in the tonnage carried was due principally to the reduction in the coal rates for distances over 200 miles.

The average rate for all descriptions of goods carried per ton per mile was 5.18 pies, as compared with 5.42 pies in 1906, or just under halfpenny, while the average distance over which a ton of goods was carried was 175 miles against 166 miles in the previous year.

The additional mileage worked, the larger traffic handled and the increase in the train mileage run necessitated a corresponding increase in the working expenses. Large sums were also expended by the principal railways in renewing their permanent way and rolling stock, and in strengthening bridges, and as a consequence the railways were worked during 1907 at 51.38 per cent. of gross earnings, against 49.88 per cent. in the previous year.

Financial Results to the State.

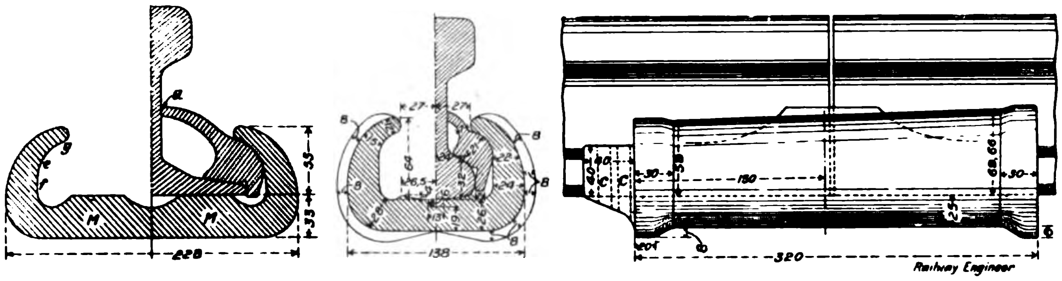
The working of the State and Guaranteed Railways for the year 1907 produced a net gain to the State of 382.79 lakhs of rupees, after meeting, in addition to the expenses of working, all charges for interest on capital outlay by the State and on capital raised by companies, and also the annuity payments for railways purchased by the State, including both interest and the portion that represents redemption of capital. This is the eighth year in succession in which there has been a surplus.

Electro-Mechanical Rail Joint.

A NEW rail-joint, 35 of which have been in use on the Paris Metropolitan R. for about a year, is shown at the Franco-British Exhibition by the *Soc. anon. des Eclisses Electro-Méchaniques*, 84, rue du Ranelagh, Paris.

This joint, the construction of which is clearly shown by the drawing, consists of only three pieces, all of which are made of annealed cast steel. The base plate or sleeve *M* (about 12⅜in. long) is placed on the ends of the rail, and two tapered keys—one on each side—are driven in with a hammer; the keys taper in opposite directions. To prevent the possibility of the slacking back of the keys they are secured by pins through one of the holes *c c*. The surfaces *f e g* are cylindrical inclined to the horizontal, and the corresponding surfaces of the keys are made to the same radius.

The mechanical advantages claimed for this joint are that it does away with fish-bolts and drilling holes in the ends of the rails, that as the ends of the rails are effectively supported any movement of them is impossible, and no shock or hammering takes place, and that "the rails take a continuous elastic curve between the sleepers as if no joint existed," and therefore that the distance between the sleepers at the joints might be increased.



Electro-Mechanical Rail Joint.

The joint has been tested at the Laboratory of the *Conservatoire des Arts et Metiers*, Paris, with the result that as compared with a similar length of the same section of rail supported with the same distance between the supports the deflection of the joint was one-half that of the solid rail without any permanent set.

Under the drop test with a weight "of 260 kgs. (585 lbs.) " and falling twice on the chair from a height of 4·02 *m* (13ft.) " and a third time from a height of 5 *m* (15ft. 3in.) the deflection was only 38·5 *m m* and rupture was produced not in the " chair but in the rail just against the rail-joint."

The electrical advantages claimed for the joint, and these are certified by *Mons.* Calve, chief maintenance engineer of the Paris Metropolitan R., are that the conductivity of the joint is equal to an ordinary fished joint and four copper bonds. The tests showed that one metre of rail with an ordinary fished joint and four wire connections gave the same electrical resistance as a plain rail 1·61*m*. long, and that one metre of rail with the new joint without wire connections gave the same resistance as a length of 1·66 *m*. of plain rail. And after the passage of 100,000 trains the joints are giving complete satisfaction.

They are also used for immediately and permanently repairing broken rails. Further information may be obtained in this country from Mr. Scott Anderson, Royal Insurance Buildings, Sheffield.

Single Phase Electric Traction on Railways.

THE electrification of the Midland line between Lancaster, Morecambe and Heysham—noticed in our last issue—and the approaching completion of the Brighton company's South London line, being the first installations of overhead construction for railways in this country, creates interest in what has been done in America in connection therewith.

There have been two such installations, both of which were brought into use last year. The first was on the Erie RR. where the work, except the power transmission line and the car bodies and trucks, was carried out and placed in operative condition by Westinghouse, Church, Kerr and Co., to whom, and to their electric traction engineer, Mr. W. N. Smith, in particular, we are indebted for the data and photographs from which this part of our notice is prepared.

The section equipped consists of 34 miles of single line, with intermediate sidings and stations, near to Rochester. Only the passenger trains are operated electrically, the goods trains continuing to be worked by steam power. Only three passenger trains in each direction were run daily before the change was made, but now there are six.

Fig. 1.

Not the least interesting feature is that the power is obtained from the Niagara Falls through the plant of the Ontario Power Co., and is conveyed at 60,000 volts three phase to the sub-station at Avon, which is about 19 miles from Rochester—one end of the electrification—and 15 miles from Mount Morris—the other end.

Fig. 1 is a photographic view of the sub-station and fig. 2 is a plan. In the lower centre is a plan of the ground floor and the opening *a* is that seen on the right of fig. 1 with the rails passing through the opening. These rails pass through the whole length of the main transformer room, in which are three transformers *b b b*, of which a view is given in fig. 3. There is a floor below which contains one of the transformer oil tanks *c*. The main transformer room extends upwards the full height of the structure so as to allow room for the high tension bus-bars to be carried over the transformers as seen in fig. 3 and in the upper left-hand and upper-centre of fig. 2 are seen these bus-bars. Another room that extends the full height of the building is the high-tension room, which is seen in the lower right-hand corner of the ground floor plan. The 60,000 volts current enters the sub-station through glass discs, *d d d*, held in 36in. tiles at the back of the building as it is viewed in fig. 1.

Fig. 3.

It passes through three circuit breakes *e e e* of the stick type and then over bare copper conductors to the three oil insulated choke-coils e^2 e^2 e^2 which are located on a mezzanine floor, approached by an iron staircase from the operating room which is on the upper right-hand corner of the ground plan. The current passes thence through three oil insulated series transformers *f f f* on the mezzanine floor and through the measuring instruments in the operating room, seen in the lower right-hand of section *c c* and terminate upon the bus-bars above the transformers *b b b*. These transformers are of the Westinghouse oil insulated water cooled type, each of 750 K.W. capacity and convert the current to 11,000 volts single phase. Only two transformers are used at one time, the third being a reserve.

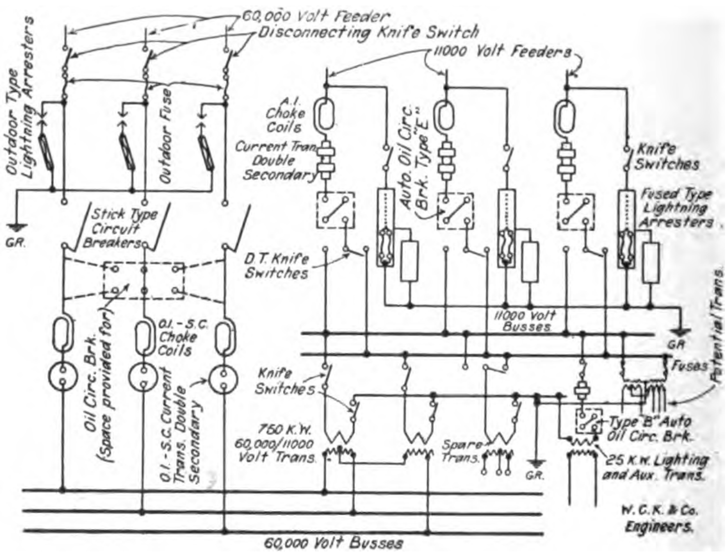


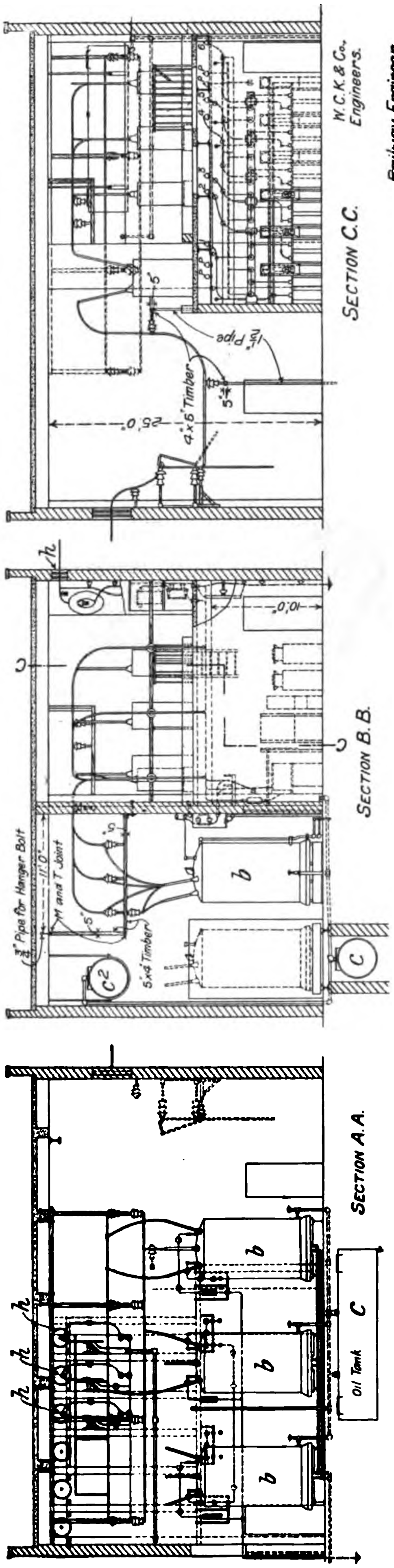
Fig. 4.—Diagram of Connections.

The railway in front of them is for the truck *g*, seen in the corner in fig. 3, upon which a transformer can be readily placed when any part requires removing for repairs. In addition to the oil transformer tank *c* in the basement there is another, c^2, suspended from the concrete roof beams at the top of the transformer room. Oil is stored in the lower tank and pumped by a steam pump—with steam from the adjoining engine shed—into the upper tank and thence fed into the transformers. From the transformers the 11,000 volts current passes up to the mezzanine floor and out through perforated glass discs *h h h* set in 18in. round tiles. Before emerging, there are tapped to them two Westinghouse low equivalent lightning arresters, set in brick compartments and reinforced by two electrolytic lightning arresters, of the 11,000 volt type. A set of call bells is provided so that should an automatic breaker open or the temperature of any transformer run above normal the men working in the adjoining car-shed are warned. The station does not require the constant presence of an attendant and the cost is consequently reduced.

Fig. 4 is a diagram of the electrical connections which may now be followed after the foregoing explanation.

The catenary trolley construction may be judged from fig. 5. The brackets, attached to chestnut poles, are of 3in. × $2\frac{1}{2}$in. T and 10ft. long, fastened to the pole by a pair of bent straps and held by two $\frac{5}{8}$in. steel truss rods. The insulator pins are of malleable iron, the lower portion being divided and fitting closely over the flanges of the T and are ordinarily about 12in. from the end of the bracket and about $15\frac{1}{2}$in. from the truss-rod, but the position of the insulator varies in this space of $27\frac{1}{2}$in. to allow for change in alignment due to curves. The messenger wire is 7 strands and is $\frac{7}{16}$in. diam., and the trolley wire is No. 3.0 B and S grooved copper, and they are joined by a $\frac{3}{8}$in. iron hanger rod spaced every 10ft. Under the T brackets are the steady strain rods hinged to a porcelain strain insulator. These are only used on curves such as that seen in fig. 5.

The span construction is practically similar to the bracket construction. Two span wires are stretched across the track, the upper one to carry the weight and the lower one to steady the arrangement. From the upper wire is suspended and to the lower is attached a piece of 3in. × $2\frac{1}{2}$in. T about 30in. long. This carries an insulator on which the messenger wire rests. On curves such as in fig. 5 and in



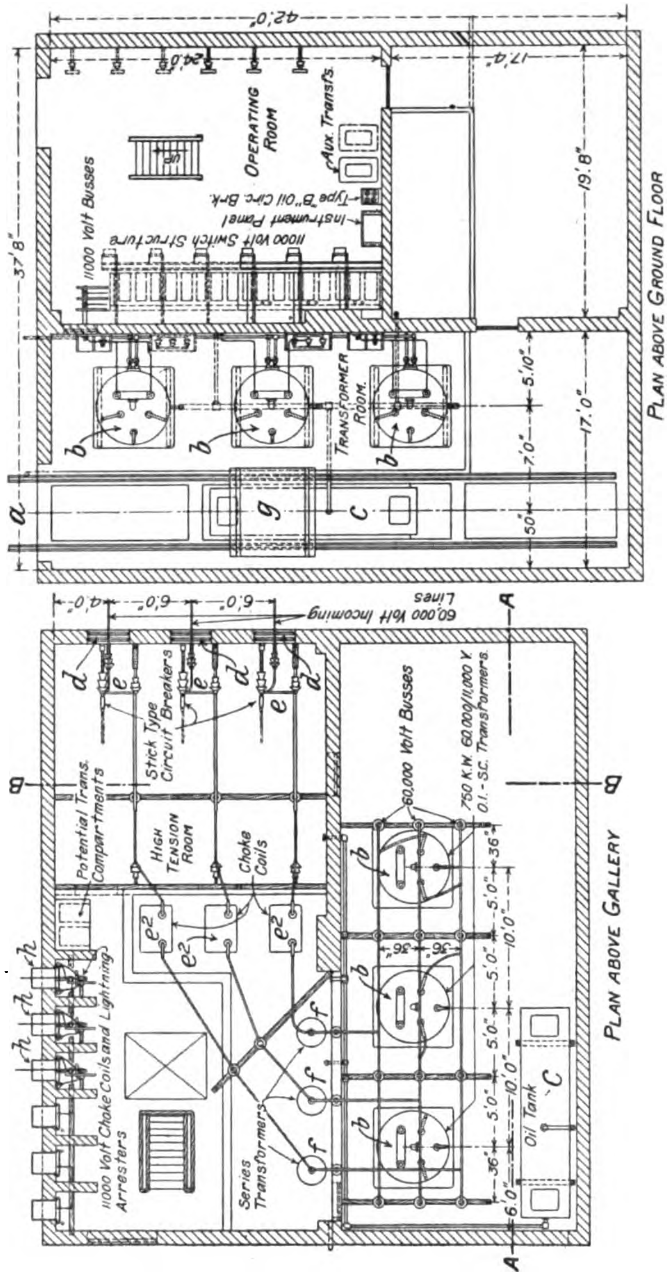


Fig. 2.—General arrangement of Switching and Transformer Equipment.

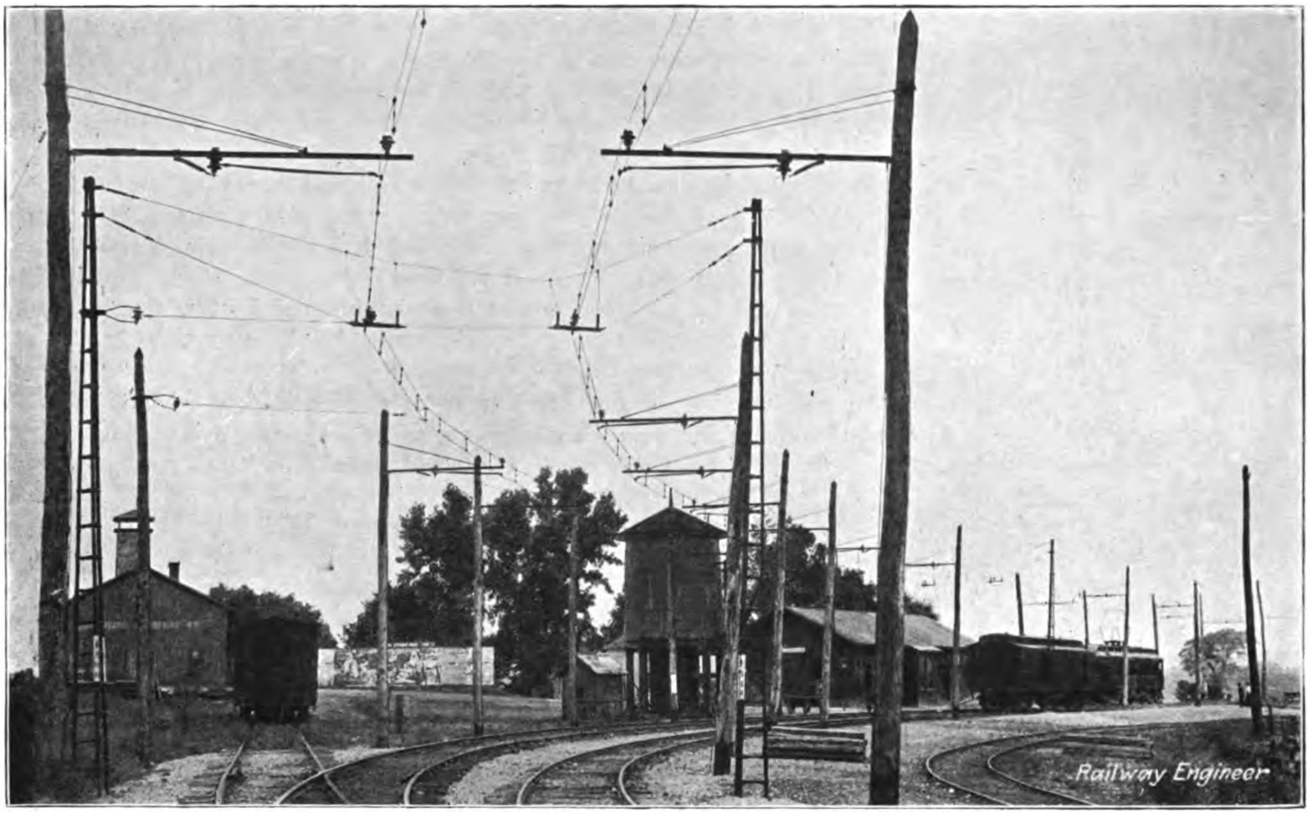


Fig. 5.

big spans as in fig. 7 "Tripartite" steel poles are used. These are made of re-rolled Bessemer rails and are set in concrete.

Fig. 6 is a view of a straight piece of work. The interlaced arrangement is what is known as a "deflector." These are four or five bars of flat steel, placed about 5ft. apart, and are intended to keep the end of the pantograph shoe from getting hooked under the other wire when passing under the trolley-wires at a siding or junction connection.

The electrical connections on the cars consists of form No. 132A Westinghouse single phase motors with a nominal rating of 100 h.p. each, the gear ratio being 20.63. The pantograph trolley mechanism is operated by a pair of springs and by an air cylinder and is raised and held against the trolley wire—as seen in fig. 7—by means of springs against its own weight. When down it is automatically locked, and the lock can only be withdrawn by applying air pressure to another small piston which then unlocks the pantograph, allowing the springs to raise it. The transformer is of 200 K.W. capacity and is of the oil insulated

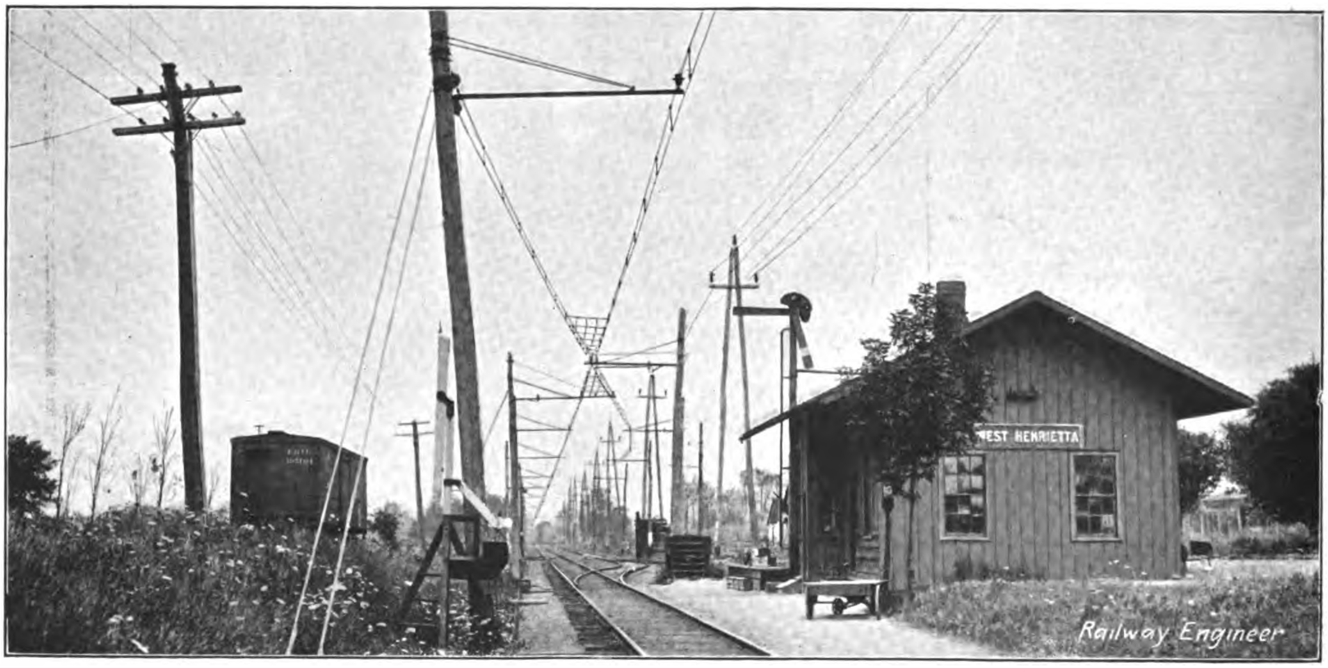


Fig. 6.

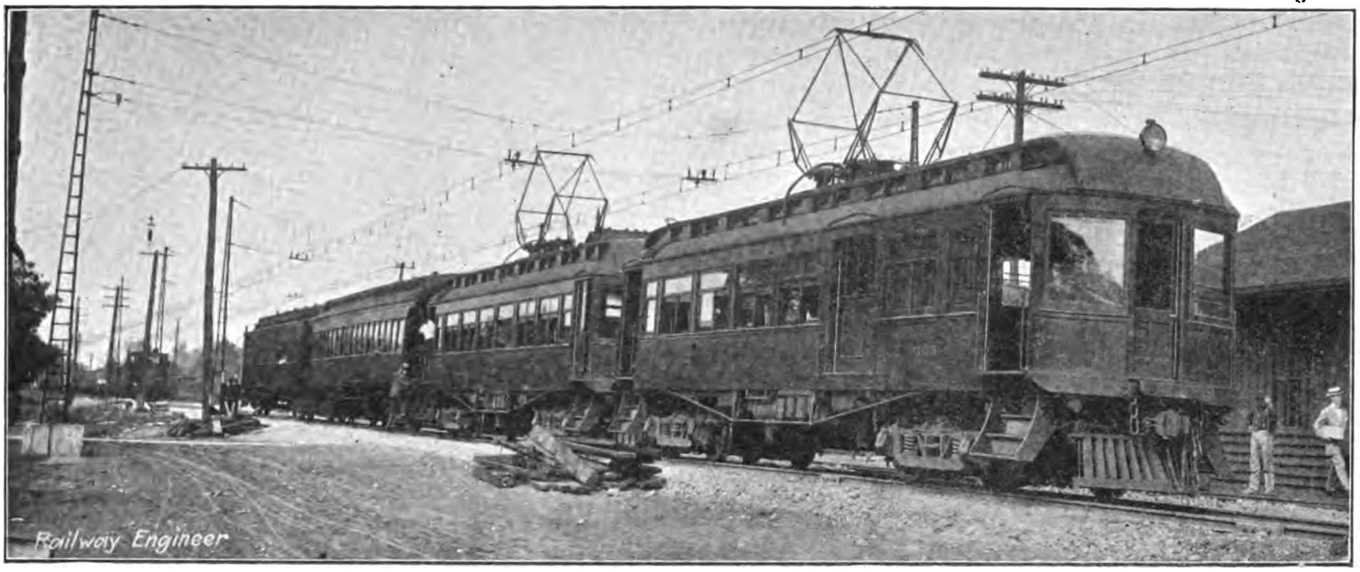


Fig. 7.

type. It has three high potential and eight low potential taps, the latter running from 300 down to 110 volts. The latter pressure current is for heating, lighting and auxiliary purposes.

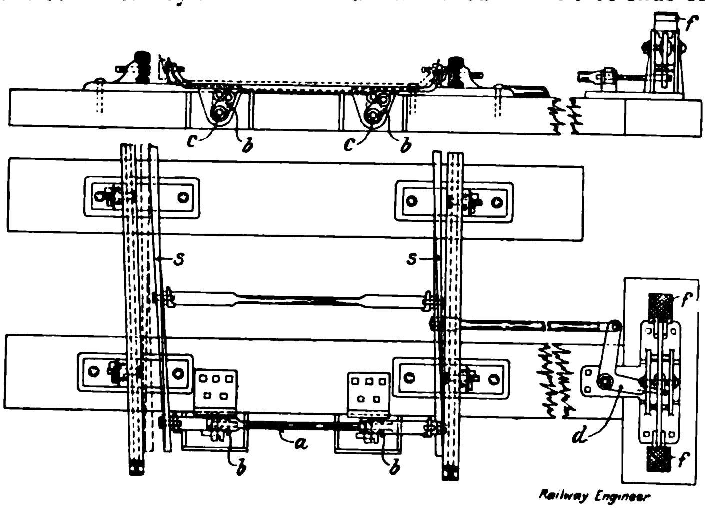
The equipment is sufficient for operating single car trains, with one stop per mile, at an average speed of 24 miles per hour, or to haul one trailer, with stops $2\frac{1}{2}$ miles apart, at the same average speed. On some trains baggage, milk and postal cars are attached. When two trailers are hauled—as in fig. 7—two motor cars are required.

The line is protected by an efficient block system, as is the greater part, if not the whole, of the Erie R. By a special feature, all risk of the motive power interfering with the telegraph service has been eliminated.

(*To be continued.*)

Gender's Slideless Switches.

THE illustration of this patent arrangement of points requires but little explanation. It will be seen that the switches *s s* are connected by a stretcher rod *a* attached to the free ends of



Gender's Slideless Switch.

two short levers *b b* rocking on centres *c c* fixed on to the sleeper. When the points are moved over it follows they must be lifted off the chairs instead of sliding on them. The points can be worked by any ordinary arrangement, but the one shown in the illustration is by means of a treadle-box, the bell-crank *d* being worked by a T lever, the arms of which carry treadle plates *f f*, which the shunter works with his foot.

These points cannot be moved when a vehicle is on them, and it is stated that the wear and tear on pins and joints is reduced by 50 per cent., and that the saving in cost of oiling and cleaning is sufficient to pay the cost of their installation in three years. A train coming through them automatically sets them with the first pair of wheels and may set back over them without fear of derailment and without the whole train first clearing them.

The sole manufacturers are W. J. Jenkins and Co., Ltd., Retford, who are showing them at the Franco-British Exhibition.

Ferro-Concrete Railway Bridges.

DURING the last few years numerous important buildings have been erected by the various railway companies in accordance with the Mouchel-Hennebique system of ferro-concrete. Among these some of the more noteworthy are the New Bridge Street Good Station and Warehouses, Newcastle-on-Tyne; Canons Marsh Goods Station and Warehouse, Bristol; and warehouses at the Royal Albert Docks, Westbourne Park, Brentford, Plymouth and elsewhere.

All the structures in question have been built from the general designs of the various engineers or architects of the railway companies, for whom details of the ferro-concrete work were prepared by Messrs. L. G. Mouchel and Partners, of Westminster.

The experience gained as to the behaviour of ferro-concrete buildings under the stress of working conditions has been so satisfactory that the same method of construction is now being applied to the construction of railway bridges and foundations in different parts of the country.

The first ferro-concrete railway overbridge completed in Great Britain was one carrying the Ripley main road across the North Eastern R. about 5 miles north of Harrogate. The bridge consists of ferro-concrete beams with the span of 35ft. It was illustrated and fully described in our issue for April last, pp. 116 and 117.

Fig. 1 illustrates another simple girder bridge with the

clear span of 27ft., designed to carry highway traffic over a new railway line near Avonmouth. This bridge was calculated for the test superloads of 140 lb. per square foot and the rolling load of an 18-ton lorry.

We believe the first ferro-concrete bridge in this country for carrying railway traffic is one built for the Dundee Harbour Board about 5 years ago. That structure comprises four main arched beams, with the clear span of 28ft. connected transversely by secondary beams and a continuous deck slab 39ft. 9in. wide. On completion of the bridge a portion of the span intended for heavy road traffic was subjected to severe tests by the harbour engineer, the greatest deflection under the total load of 62 tons 6 cwt. being less than $\frac{3}{16}$in., or only 1/1855 of the span.

A more recent example of ferro-concrete railway bridge construction is the three bridges carrying main line rolling stock over Victoria Street, St. Phillip's Marsh, Bristol. (See fig. 2)

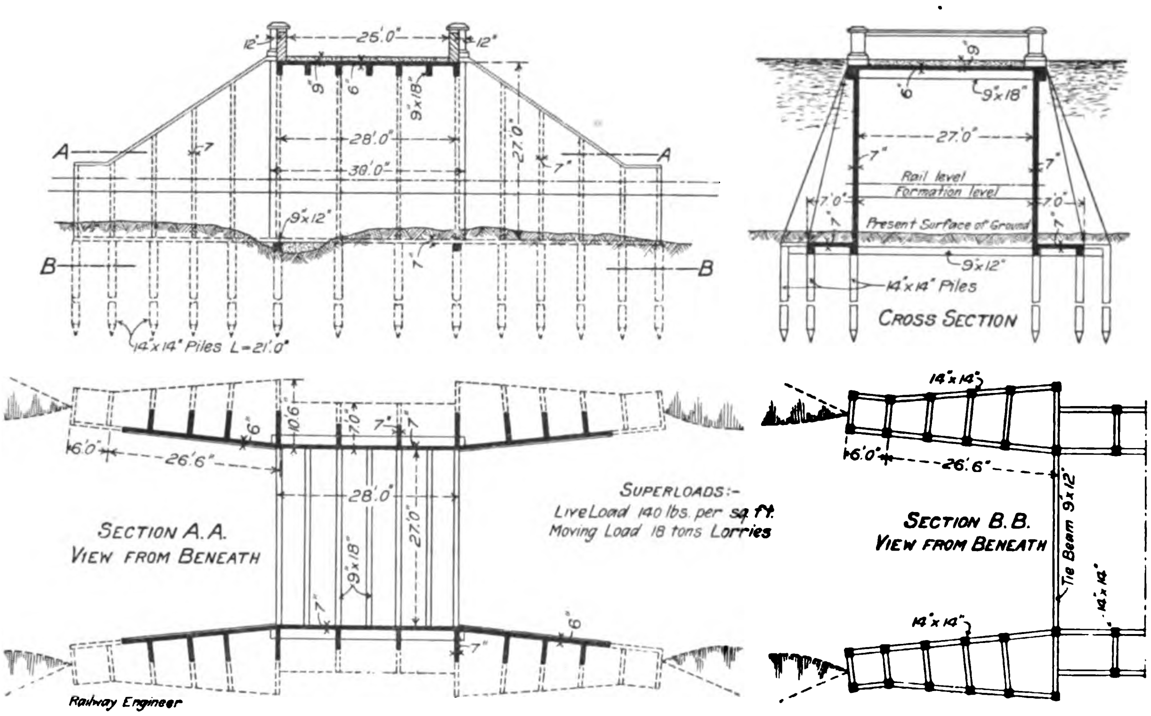


Fig. 1.

Although these structures are not of imposing character, they are of special interest as representing the first ferro-concrete bridges to be used in this country for main line rolling stock.

All three bridges are of the girder type, the three skew spans being supported on ferro-concrete walls, built up from piles of the same material. The clear span measured perpendicularly to the supporting walls is 36ft. in each case, and the overall width of the connected series of bridges is 196ft. approximately. Owing to the gradient of one of the lines the middle span is 5ft. higher than the two outer spans, the three bridges being connected by two slopes of ferro-concrete.

The ferro-concrete foundation piles, in two rows 9ft. apart centre to centre, on either side of the street measure 14 by 14 and are driven to a sufficient depth to ensure absolute security. They are connected at the heads by longitudinal and transverse beams, which in turn are connected by continuous horizontal slabs, whence rise the vertical face wall counterforts and columns carrying the ends of the girders above.

The cross section and plan show the manner in which the two supporting walls are tied by horiontal beams passing beneath the roadway. These beams were moulded and seasoned in advance so that they could be laid in position and bonded to the other ferro-concrete work without interference with vehicular traffic along the street.

The counterforts are 12in. thick and are spaced at intervals of from 8ft. to 11ft. apart centre to centre, and between them are columns measuring 12 by 18 similarly spaced, the latter members and some of the counterforts being immediately below the ends of the main girders of the bridge spans.

As the chief duty of the face wall on either side of the roadway is to hold up the earth filling, these parts of the construction are only 5in. thick, which is quite adequate in view of the ample reinforcement applied for withstanding the stresses due to flexure.

The main girders, 12in. wide by 26in. deep, cross the street at different angles in the three spans and are connected by a continuous decking slab 7in. thick, upon which the permanent way is laid.

From this brief description it will be seen that the whole construction is of exceedingly simple character, and we may add that owing to the monolithic connection between all the members of the ferro-concrete work and the careful manner in which the ends of the reinforcing bars of one part are anchored into the concrete of adjoining parts, the rigidity of the bridge should prove superior to that of a framed structure of the customary construction.

The Victoria Street bridges were designed for the rolling test load of an 80-ton locomotive with the wheel-base of 27ft. 9½in.

Another bridge for main line traffic in the same locality is

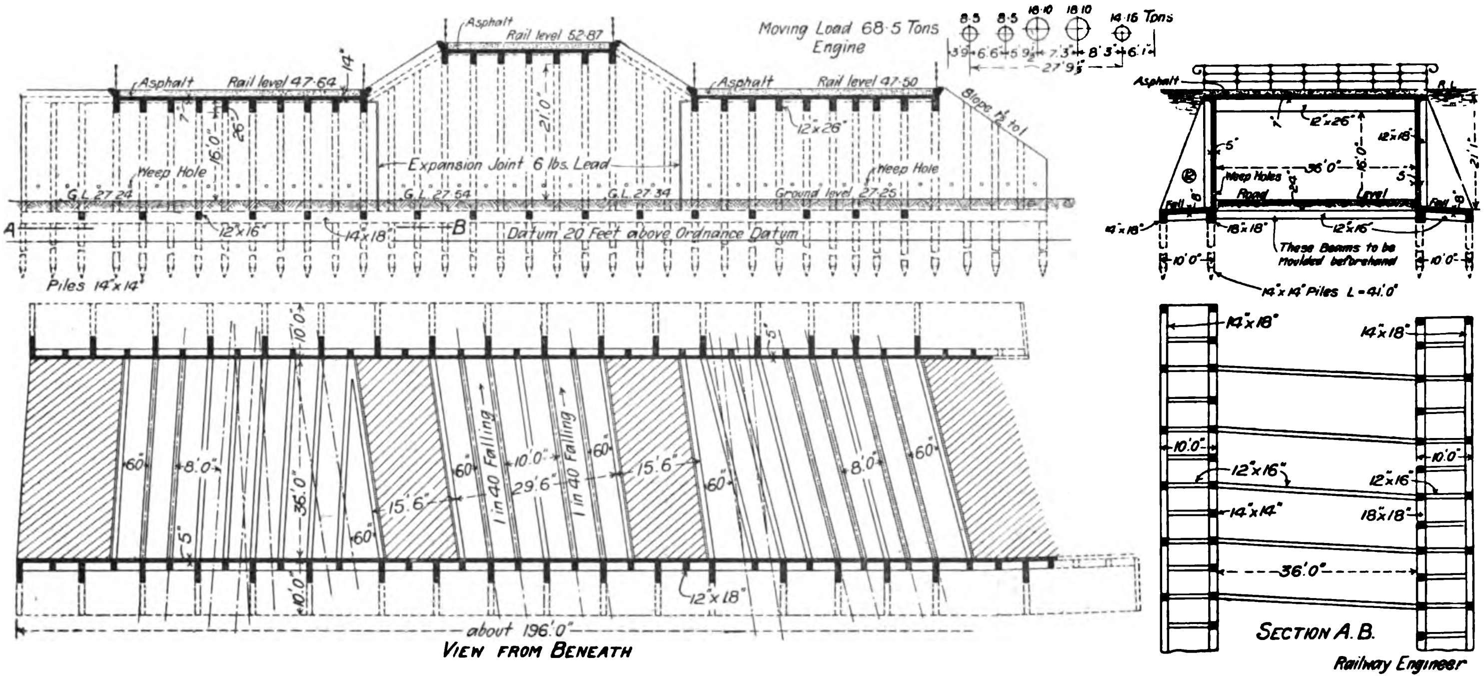


Fig. 2.

on the new line affording direct communication between London and Avonmouth.

As shown by fig. 3, the bridge consists of a single arch, with the clear span of 24ft., formed by a curved slab of ferro-concrete 8in. thick at the crown and 14in. thick at the springings. The abutments and wing walls are generally similar in filling over the span proper, and the wing walls, being tapered down as represented in the cross section, serve a similar purpose by holding up the embankment.

This bridge was designed for the moving test load of an 80-ton locomotive.

The bridge abutments are built upon a thin slab of ferro-

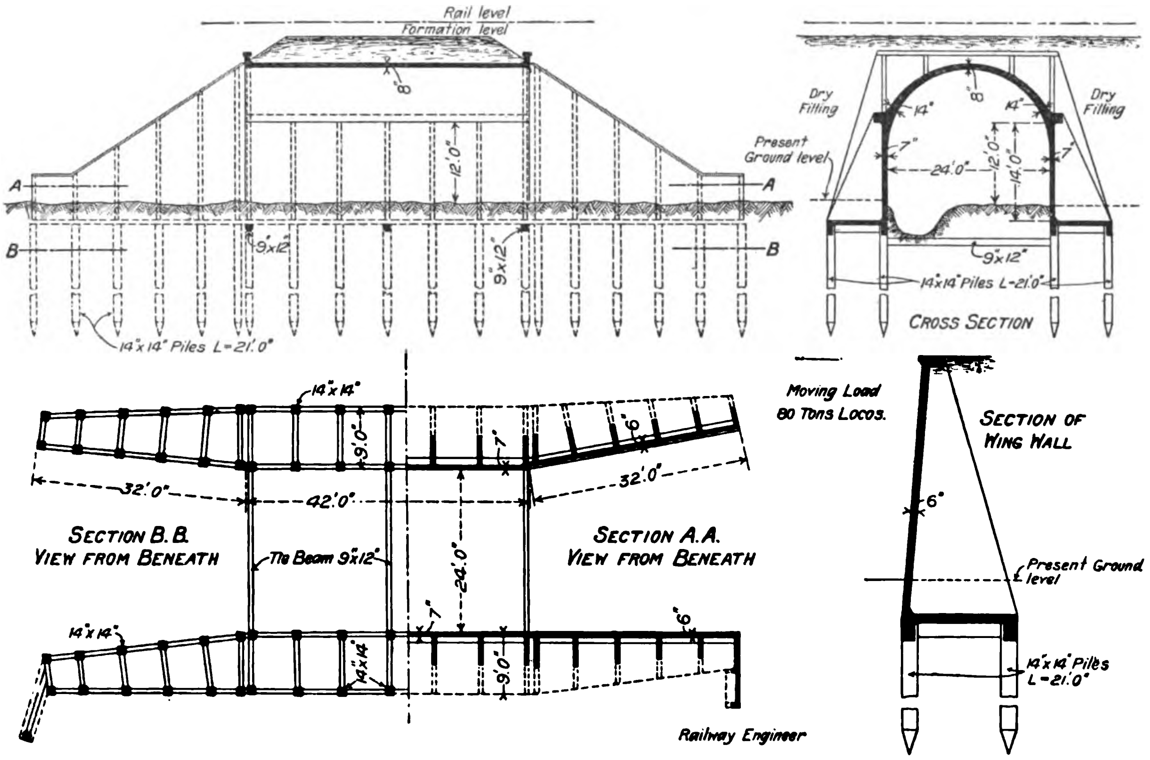


Fig. 3.

design to the walls supporting the Victoria Street Bridge above described, although in the case of the work now under consideration the abutments are reinforced with special regard to horizontal arch thrust.

Spandrel walls, built monolithic with the arch and stiffened by two columns on each side of the crown, serve to retain the concrete stiffened by ribs of the same material. The slabs and beams are moulded upon ferro-concrete piles 14in. square by about 56ft. long, constituting foundations of particularly rigid and stable character, and imposing far less load upon the soil than would be involved by mass concrete foundations of the customary description.

Ferro-concrete has recently been employed for the foundations of several railway bridges, and in the construction of culverts through railway embankments in different parts of the country. One of the most important works among these is represented by the foundations of the new latticed girder bridge of 200ft. span carrying a branch of the North Eastern R. across the River Aire near Goole.

The foregoing examples show that British railway engineers are beginning to recognise the value of ferro-concrete for bridges where steelwork is particularly liable to corrosion.

The Pintsch-Howard System of Pneumatically-Working Fans on Railway Carriages.

THE greatest advantage of electrically lighting railway carriages is that the current is also available for working fans or wavers for ventilation or air agitation.

To meet this demand on carriages fitted with oil-gas or any other (except electric) system of lighting, the system here described has been introduced by Pintsch's Patent Lighting Co., London, E.C., and which consists of compressing air into a reservoir under the carriage and leading pipes from the reservoir to the fans. The general arrangement is shown by fig. 1.

One of the carriage axles is fitted with a pulley B similar to those used for axle lighting, and a small air compressor A is suspended from the underframe by swinging links. The stretch of the belt is taken up and the tension regulated by the spiral spring D, which is kept slightly in compression.

In order that, as far as possible, clean air only may be used, the intake pipe may be carried to any position in the carriage, or if on the outside it may be carried up the end of the carriage, the end of the pipe being turned downwards. In any case the open end should be covered with fine gauze or other suitable substance so as to filter the air.

As the air is drawn into the compressor it is forced by way of the flexible copper tube H into the reservoir F until the pressure reaches 100 lbs. per square inch, when the safety release valve E on the compressor comes into operation, the inlet valve to the compressor being raised so that the compressor can run light until the pressure falls below 100 lbs., when the valve closes and compressing again takes place. As a further safeguard, a supplementary safety valve G is fitted on the end of the reservoir. This valve is adjusted to operate at 105 lbs. per square inch. The air in the reservoir flows through a ¼in. high-pressure pipe to the regulator J, which is made on the principle of the well-known Pintsch gas regulator.

The regulator may be adjusted to give any pressure according to the number of fans and the speed they are required to run. The usual pressure is 8 lbs. per square inch. This will run the fans at about 400 revolutions per minute, and four fans will run for about 30 minutes when the reservoir is fully charged. The fans themselves are driven by air motors made upon similar lines to those used for the Howard pneumatic tools. As will be seen, the pipes are all of small bore, so that there may be as little difficulty as possible in running the pipes through the carriage. The revolutions of the compressor should not exceed 470 at the maximum speed of train.

Fig. 2 is a view of the air compressor.

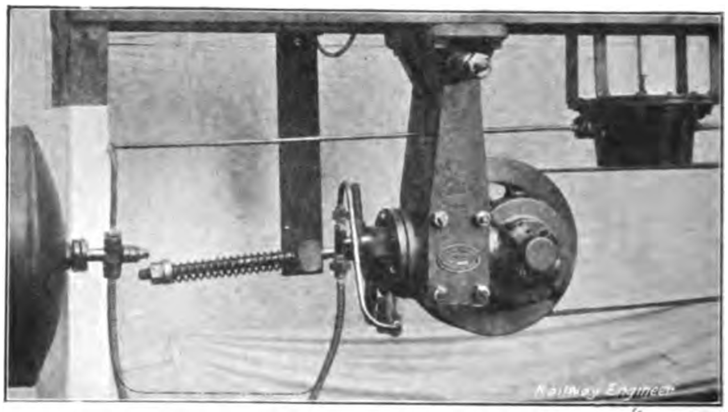


Fig. 2.—View of Air Compressor.

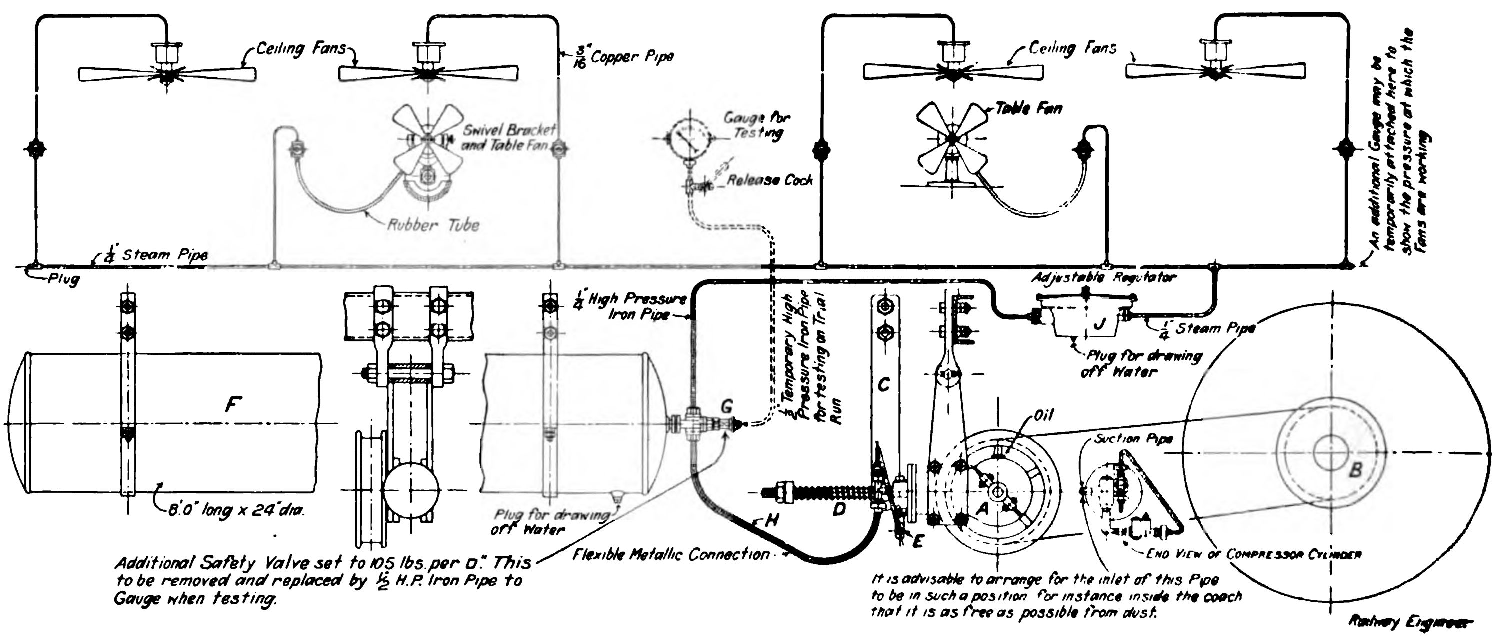


Fig. 1.—Pintsch-Howard System of Pneumatically-Working Fans on Railway Carriages.

Locomotive Journals and Bearings.—VI.*

North British Railway.

LIKE other railway companies, the North British has greatly increased the power of its modern engines. The main line of the North British R. forms an important part of the East Coast route, the express trains on which are both heavy and fast. Corridor trains are run in competition with the Caledonian R. between Glasgow, Edinburgh and Aberdeen. The gradients that have to be negotiated are very steep.

For this work Mr. W. P. Reid, locomotive carriage and wagon superintendent, has adopted the "Atlantic" or 4-4-2 type of engine with cylinders 20in. by 28in. and 6ft. 9in. coupled wheels. The heating surface of the boilers of these engines is 2,256·2 sq. ft.; the grate area 28·7 sq. ft.; the working pressure is 200lbs. per sq. in., and the weight 67·1 tons, of which 40 tons is on the coupled wheels.

The details, of which Mr. Reid has been good enough to give us the drawings, belong to these engines.

Leading and Driving Axle Boxes, fig 25. These axle-boxes are designed for a bearing 8⅝in. long, the journal being 9in. diam. by 9in. long. They are made of bronze, with four wedge-shaped white-metal insets, arranged as shown on the drawing. The box is 14in. wide between the horn-block surfaces, and 9⅜in. deep from the centre to the top. The horn surfaces are 18in. by 6$\frac{5}{16}$in., the horns being 6¼in. wide. The bearing is eased away at the sides as shown, and also along the crown.

The top of the box is cored out, but the lubricating oil is fed from a box on the splasher, and drips into a cone leading through a ⅜in. hole to a trough ⅜in. wide by ½in. deep along the crown of the bearing. There is also a pad in the keep pressed up to the journal by flat bow springs as shown.

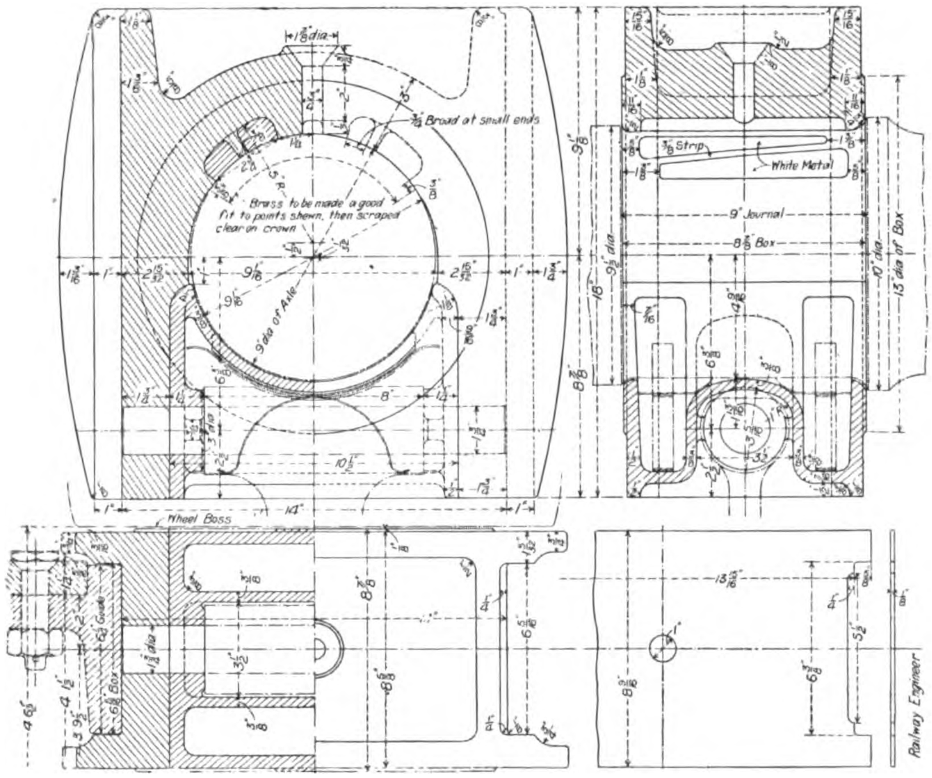


Fig. 25.—Leading and Driving Axle Boxes; North British Railway.

*Previous articles in February, March, May, June and July, 1908.

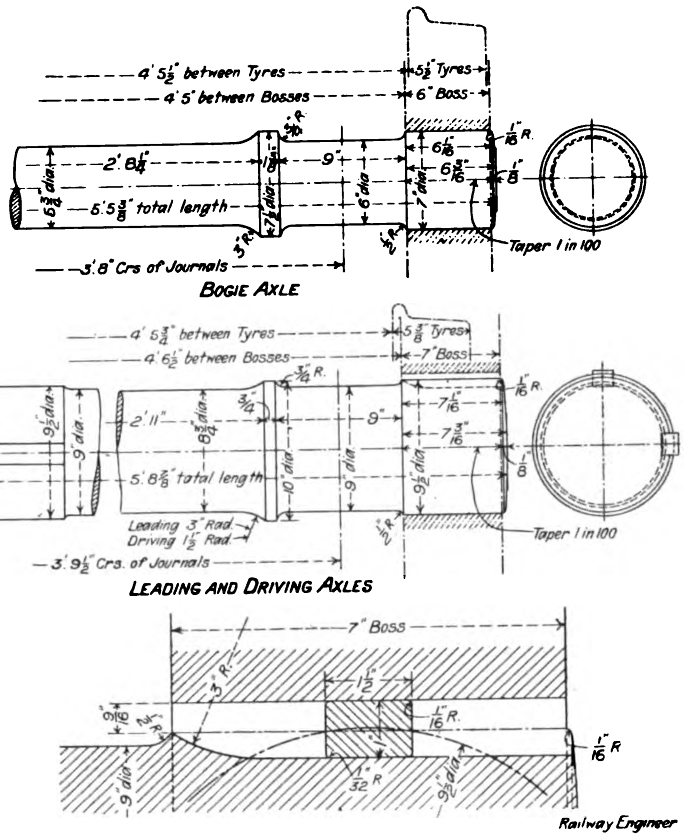


Fig. 26.—Driving and Bogie Axles; North British Railway.

The Keep is of cast-iron, and is supported in its place by the spring-link pin, which is 1⅜in. diam.

The box is provided with a plain sheet steel cover ⅛in. thick, and shaped as shown on the drawing.

Driving and Bogie Axles, fig. 26. These are of steel, and are fully dimensioned on the drawing. The wheel seats are tapered at 1 in 100. The object of this slight taper is to prevent the wearing of the surfaces while the wheel is travelling into its place on the axle. Two keys, at right angles, are used to key the driving wheels. The key-way has fillets in the corners $\frac{1}{32}$ in. radius, and its bottom is milled to rise out of the axle as shown.

Connecting-Rod, fig. 27. This is an outside (right hand) rod, and has solid ends, and differs from any of the others we have illustrated. It is 11ft. 3in. long between the centres, and is made of steel. Both ends are fitted with adjustable gun-metal bushes. The Big-End bearing is 6in. diam. by 5$\frac{7}{16}$in. (pin 5½) long, and is fitted with four large white-metal insets. The bush is 8¼in. by 7¼in., and has its outer corners rounded to 1in. radius. The eye of the rod has a section of 2¼in. by 3½in. at the end and 1⅝in. by 3½in. at the top and bottom, all the corners being well rounded off as shown. The end brass is retained by flanges, and the inner brass by flanges and a steel wedge, which in turn is secured by the steel adjusting cotter, which is ⅞in.

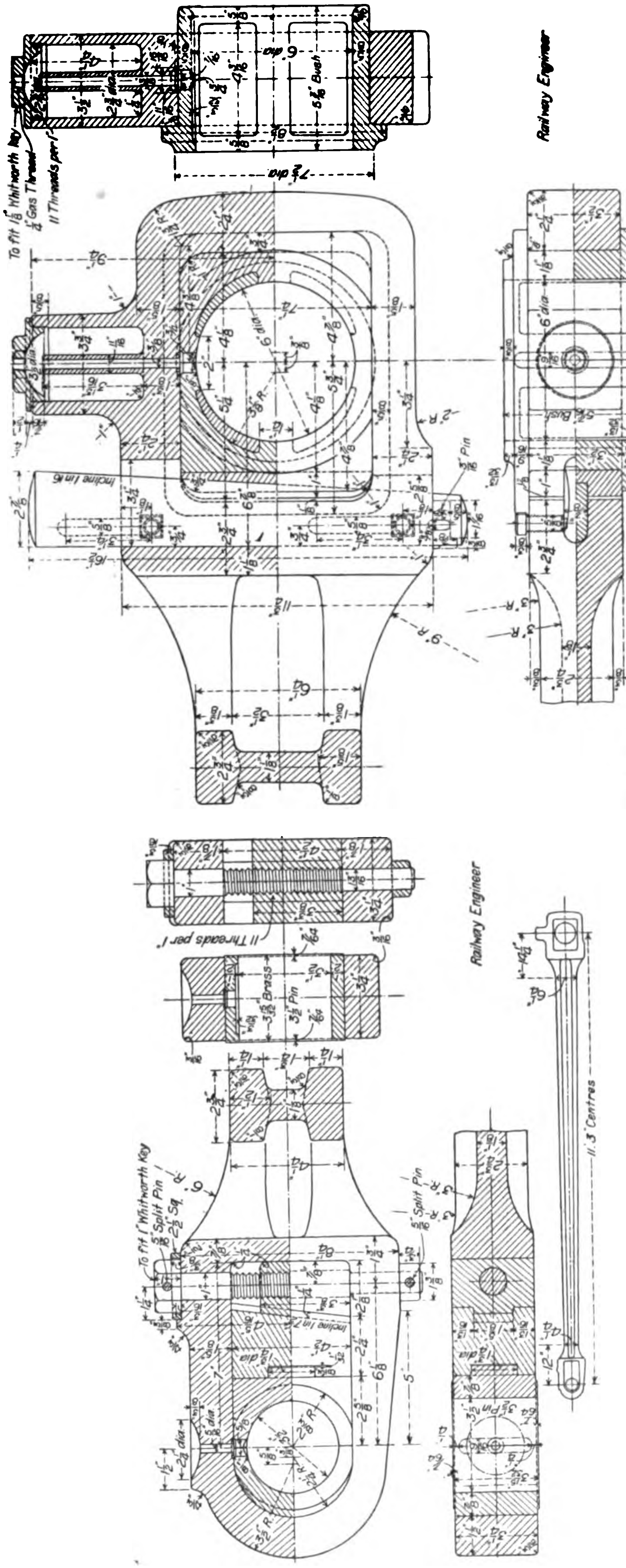


Fig. 27.—Connecting Rod ; North British Railway.

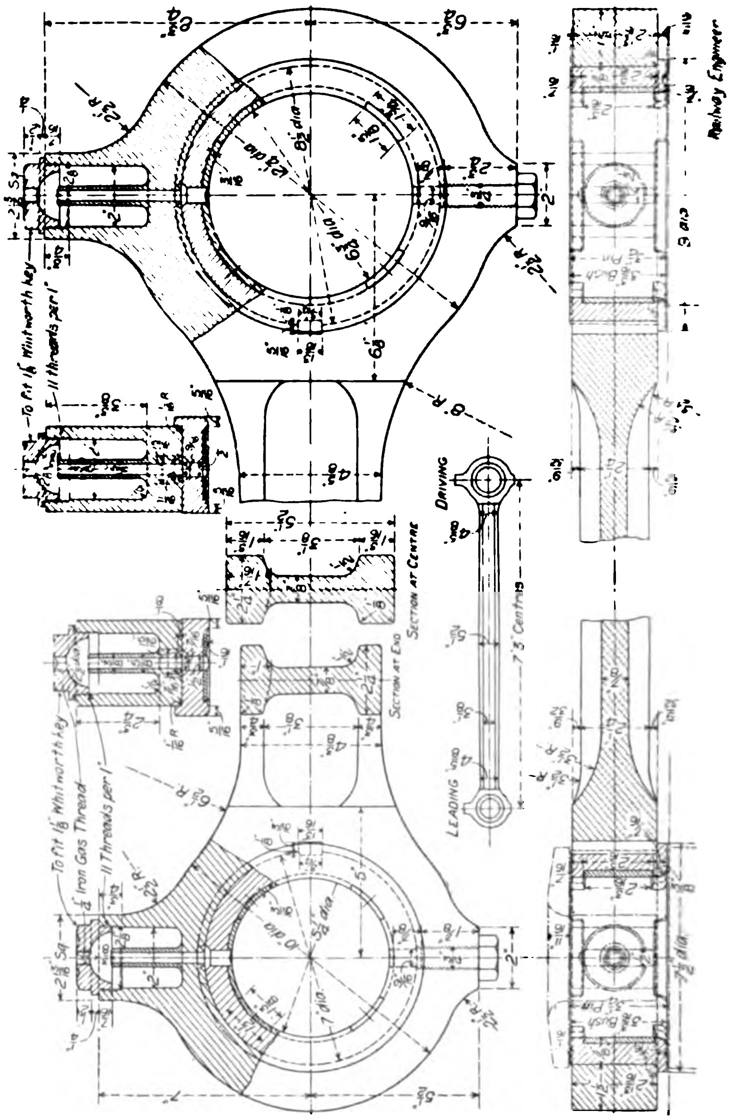


Fig. 28.—Coupling Rod ; North British Railway.

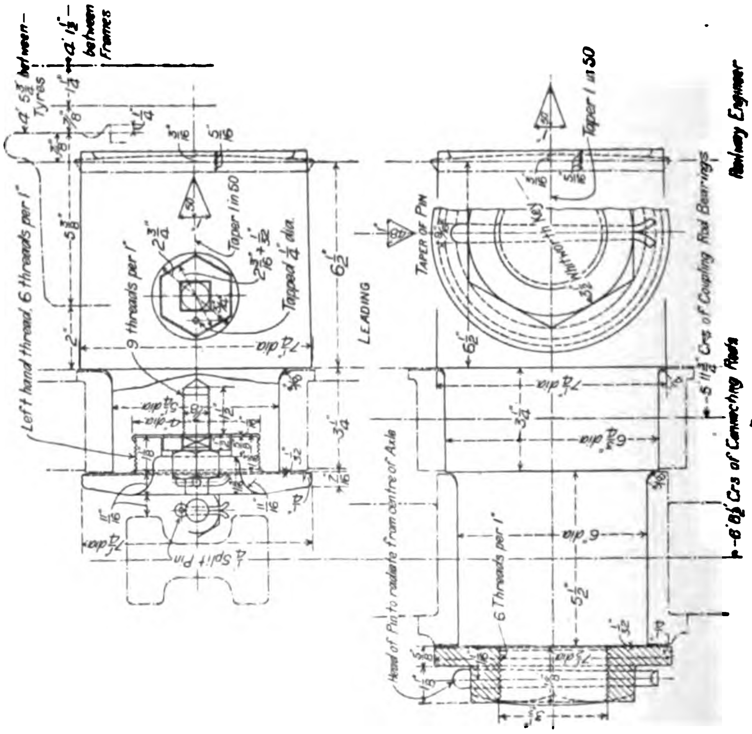


Fig. 29.—Crank and Coupling Rod Pins ; North British Railway.

thick, and tapers from $2\frac{7}{8}$in. at 1 in 16 for a length of $16\frac{1}{2}$in. The cotter is secured by two $\frac{5}{8}$ steel set-screws and by a safety key $\frac{5}{8}$ by $\frac{3}{8}$ at the bottom.

The Rod has an I section, and tapers from $6\frac{1}{4}$in. to $4\frac{1}{4}$in., with a uniform width of $2\frac{3}{4}$; the web is $1\frac{1}{8}$in. thick, with fillets to the heads of $\frac{3}{8}$in. radius; the top and bottom corners of the heads are taken off to $\frac{3}{16}$in. radius and the inner ones to $\frac{1}{8}$in.; the heads taper from $1\frac{3}{8}$in. to $1\frac{5}{8}$in. towards the web as shown.

The Oil Cup is solid, with the rod $3\frac{1}{2}$ by $3\frac{3}{4}$ externally, and based out to $2\frac{3}{4}$in. diam. inside. It is closed with a brass cover, screwed in through the centre of which is a feed hole tapped $\frac{1}{4}$in. gas thread for a wooden or cork plug.

The Small-End bearing is $3\frac{1}{2}$in. by $3\frac{15}{32}$ (pin $3\frac{1}{2}$) in. The adjusting wedges are of steel and are grooved into each other as shown, and the bush has a projection $1\frac{3}{4}$in. diam. which fits into (without bearing at the bottom) a recess bored in the wedge. The moving wedge block is threaded on a bolt 1in. diam. which is locked by a washer $2\frac{1}{2}$in. sq., which fits over the hexagonal head of the bolt, and is prevented from turning by a ridge across the rod as shown. The washer is secured by a $\frac{5}{16}$ split pin. The smallest section at the front end of the eye of the rod is $1\frac{1}{2}$in. by $3\frac{1}{4}$in.

Coupling-Rod, fig. 28. This is of steel 7ft. 3in. long between the centres. The driving bearing is $6\frac{3}{4}$in. diam., and the leading bearing is $5\frac{1}{4}$in. diam., both being $3\frac{3}{16}$ (pin $3\frac{1}{4}$) in. long. The bushes at both ends are of gun-metal lined with white-metal $\frac{3}{16}$in. thick, and which in four places is the full length of the bearing as shown. The bushes are prevented from turning by steel keys slightly riveted over at the ends, and by $\frac{3}{4}$ steel set-screws the ends of which project into the white-metal. The eyes of the rod are $12\frac{1}{4}$ and 10in. diam. respectively by $2\frac{13}{16}$in.

The Rod is machined to an I section, the depth of which tapers from $4\frac{5}{8}$in. at the driving end to $5\frac{1}{2}$in. at the middle to $4\frac{3}{8}$in. at the other end, and the width of the heads $2\frac{1}{4}$in.; the web is $\frac{7}{8}$in. thick, the fillets from the heads to the web are $\frac{1}{2}$in. radius, and all the corners are rounded off to $\frac{1}{8}$in. radius. The lubricators are solid with the rod, and are in all respects similar to those of the connecting rod above mentioned.

The driving-end of the coupling rod is retained on the pin by the connecting-rod, which is retained by a large steel flanged nut screwed (6 threads to the inch) on to the end of the Crank-pin, and a pin tapered at 1 in 48 is put through the nut and pin radially, its small end being split and opened as shown by the drawing of the

Crank and Coupling Rod Pins, fig. 29, which are tapered at 1 in 50 in the wheel, and riveted over as shown. The Crank and Coupling-rod Pins are of steel.

The small end of the coupling rod is retained on its pin by a steel washer $7\frac{1}{4}$in. diam. screwed by a left-hand thread (6 per inch) into the end of the pin. The washer is recessed and has a hexagonal hole in its centre, and into this fits a washer ($2\frac{7}{32}$ over flats), which has a square hole in its centre that fits the square neck of a $\frac{7}{8}$ steel stud tapped into the centre of the coupling-rod pin, and is secured in its place by the hexagonal nut of the stud. A $\frac{1}{4}$in. split pin is put through the end of the stud as shown. The end of the stud does not project beyond the face of the washer.

(To be continued.)

Train Protection on American Railways.

THE twenty-first annual report of the Intestate Commerce Commission is the latest issued, and by it we learn that the railways of the United States on June 30th, 1906, consisted of:—Single lines, 222,340·30 miles; double lines, 17,936·25 miles; three lines, 1,766·07 miles; four lines, 1,279·66 miles; sidings, 73,760·91 miles, or a total of 317,083·19 miles of road.

Within the last few weeks a Return has been issued by the Commission as to the mileage protected by automatic signals or the block system on December 31st last, and which states that there were 151,455 miles open for passenger traffic.

Of these, 10,803 miles were protected by automatic signals, and 47,875 by the block system.

The various systems of automatic signalling are in use as follows:—497·6 miles are equipped with clockwork signals; 1,838 with disc signals; 416·7 with electro-pneumatic signals: 7,143·9 with electric motor signals; and 923·1 miles with electro-gas signals. These figures include 16·3 miles on the Philadelphia and Reading RR. that are purely goods or mineral lines.

The Return shows that of the mileage protected by block systems 40,040·3 miles have Morse telegraph instruments; 3,286·8 miles telephones; 838·5 miles (722·1 miles are on the Erie) electric bells; 6,179 miles manual-control—lock-and-block—and 234 miles electrical train-staff. Of the 6,179 miles protected by manual-control 5,240·3 miles have no track-circuits, 726·7 miles have track circuits at stations, and 212 miles are track-circuited throughout. The total of these (50,578·6 miles) does not agree with the total quoted above (47,875·7 miles), but no explanation is given as to the discrepancy.

It should be noted that owing, principally, to both State and Federal legislation having made it illegal for any telegraph operator to be employed for a longer period than nine hours at a stretch the telephone is now being extensively employed for block purposes. In case our readers should condemn this method on the grounds that there is no visual indication of the signals given and received, we would remind them that the same objection applies to all forms of block used in America except the manual-control. But any "system" is better than none.

Of the 47,875 miles protected by the block system, on only 10,039·9 miles is absolute block-working employed for all trains. Permissive working is allowed on the remaining 77 per cent. of the lines, but on a good many of these absolute working is required for passenger trains.

Of the companies possessing more than 2,000 miles of passenger lines the percentage protected by the block-system or automatic signals is as follows:—Atchison, Topeka and Santa Fé, 19·9; Atlantic Coast Line, 14·1; Baltimore and Ohio, 35·6; Boston and Maine, 13; Chicago and North Western, 41·4; Chicago, Burlington and Quincy, 98·7; Chicago, Milwaukee and St. Paul, 70·2; Chicago, Rock Island and Pacific, 15·3; Great Northern, 5·2; Illinois Central, 18·8; Louisville and Nashville, 13; Missouri Pacific, 7·3; New York Central, 99·5; New York, New Haven and Hartford, 46·4; Northern Pacific, 22·7; Pennsylvania, 69·8; St. Louis and San Francisco, 8·1; Seaboard Air Line, 8·6; Southern, 26·9; Southern Pacific, 32·2; Union Pacific, 40·8.

Some of the above records do not read well, but only three or four years ago they were worse. During the fifteen months prior to the end of last year no less than 5,959·4 miles were equipped with the block system and 3,976·1 miles with automatic signals. Of the latter figures 2,331·1 miles were for single lines. It may further be remarked that Mr. Kruttschnitt, the director of maintenance for the Harriman lines, informed the writer as recently as last May that the Union Pacific and Southern Pacific companies were just finishing the largest and most complete installation of automatic signals in America, namely, the equipment of about 4,700 miles of road, of which nearly 4,000 are completed, and that, during the last ten years, those two companies had spent on safety devices of all kinds no less than 12,000,000 dollars.

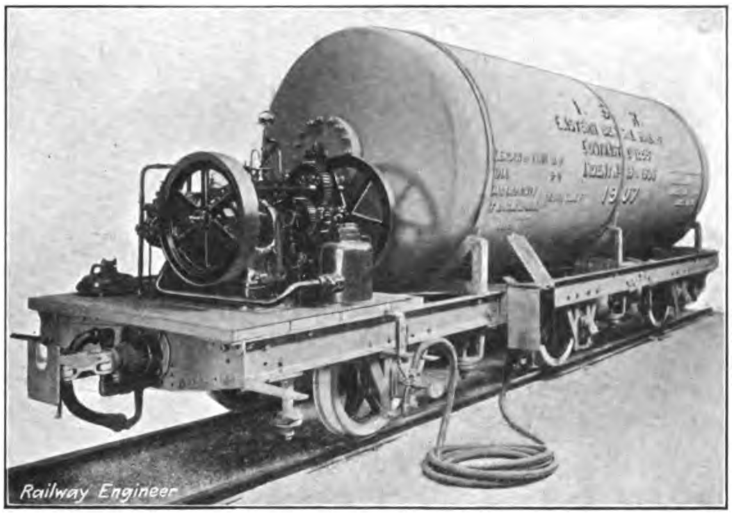
Portable Oil-Gas Compressors for Train Lighting.

In countries, such as India, where the railways extend very much further from the base than is the case in this country the cost of recharging oil-gas reservoirs, either on the carriages or at stations, has been more costly than it otherwise would be, because all the gas cannot be taken from the travelling holders.

The ordinary maximum pressure in the tanks under the carriages is 7 atmospheres or approximately 105 lbs. per sq. inch, and the pressure in the travelling or storage holders is ten atmospheres or 150 lbs. per sq. inch.

When gas is drawn from the high pressure holder to the carriages it follows that the pressures will balance when the gas in the former is reduced to a pressure of 105 lbs., therefore there is a considerable quantity of gas in the holders which is returned to the gas works. With the object of reducing this waste haulage of gas-tanks Pintsch's Lighting Company have introduced a compressing pump, driven by a Tangye gas engine, which can be fixed to the travelling holder or placed by stationary holders at outlying stations, and several of them have been supplied to the Indian Railways.

The accompanying illustration shows a traveling holder as supplied to the Eastern Bengal, metre gauge system.



Portable Oil-Gas Compressor.

The holders are made seamless, so that there can be no loss by leakage at the points, due to constant vibration, as is the case with rivetted holders. The tank in this case is 18ft. long by 6ft. diameter, with a capacity of 5,040 cubic feet at a pressure of 10 atmospheres. The underframe is 24ft. 6in. long, mounted on six wheels, with a total wheel base of 16ft.

The gas engine and compressor, on one bed plate, are fixed at one end, and can be used to compress gas into stationary holders or into those under the carriages.

On the North-Western of India and other standard (Indian) gauge lines three holders, 19ft. 4in. by 4ft. 2in. dia., having a total capacity of 7,500 cub. ft. at 10 atmospheres, are placed on one underframe, one holder being placed above and between the other two. The four-wheeled truck is 24ft. long and the wheel base 16ft.

Gas is drawn from one cylinder first, and when the pressure is reduced gas from either or both of the others can be compressed to the required pressure into the last holder and finally, if necessary, into the stationary holders or into those under the carriages.

Permanent Way.—I.

In a series of articles under the above title it is intended to treat of the constituents that make up the conglomerate "Permanent Way," viz.:—ballast, sleepers, chairs and fastenings, rails and joints, points and crossings, junctions, crossovers, slips, catch-points, ground levers, etc. These constituents will be dealt with in detail and fully illustrated, as they vary considerably on different railways. Several of them offer wide and interesting fields about which comparatively little has been written in recent years, during which the ever-increasing weights of locomotives, the speed, frequency and weights of trains and the introduction of electric traction have caused engineers to give much more attention to the strength and condition of the roads under their charge.

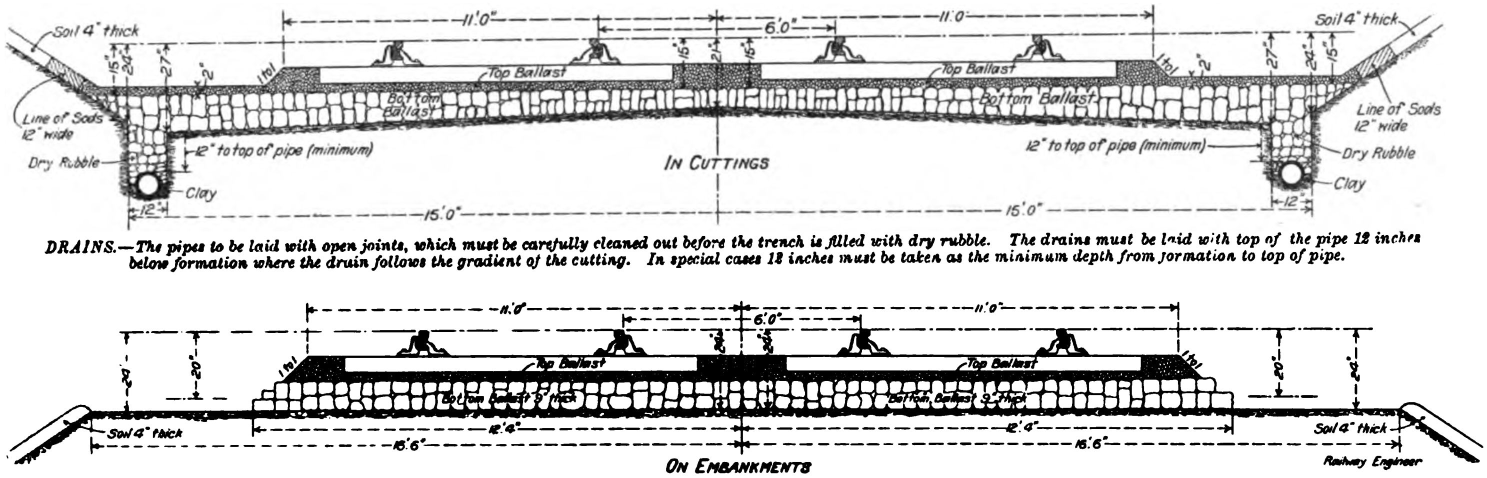
Thus under the heading Ballast will be considered the varieties of stone and other materials used for top and bottom ballast, stone breaking plants, ballast wagons and spreaders. The consideration of Sleepers naturally includes those of wood, metal and the more recently introduced material ferro-concrete, the dimensions of sleepers, whether cross or longitudinal, the woods used and their preservation by creosoting, chemical and other processes. On Rails and their manufacture much has been written and their sections and chemical composition have been recently standardised. This standardisation is more useful to foreign and colonial buyers and small consumers generally than to large railway companies, the size of whose orders compels rollers to supply exactly what experience has taught permanent-way engineers best suits the particular climatic and other conditions of their railway without being mulcted in extra charges. The handling, bending and cutting of rails and the tools and appliances used in connection therewith are all matters of interest to the engineer. The full consideration of Points and Crossings, built up and solid, must cover not only their design but the steel and rail sections, and also the special machine tools used in their manufacture. The patterns of chairs and sole-plates and of keys, trenails and other fastenings vary on nearly every railway. All of them are required in large quantities and some pass through several processes and require special machine tools to reduce the cost of their manufacture. No part of the permanent-way gives the engineer more cause for anxiety than the joints of the rails, and the variety of fish-plates, fish-bolts and patent joints is legion: some of the last have been used in quantities, with more or less successful results.

The permanent-way of British railways is generally admitted, by impartial engineers whose opinion is worth attention, to be the best in the world. There are, in the Eastern States of America, hundreds, perhaps thousands, of miles of equally good "road." The writer has been over it all many times. The salient differences between British and American permanent-way are that in the former the rails are keyed into chairs fastened to the sleepers with the rail-joints opposite, and in the latter the flanged rails—with sole-plates between the rail and the sleepers—or ties as they are termed in America—are spiked direct on to the sleepers. On the merits and demerits of these two systems much has been said and written—the most blatant critics, be it remarked in passing, not being engineers, but those who have never had a yard of line in their charge. Among engineers the advocates of both systems generally leave off where they began, neither side being convinced. This is,

of course, for old countries with a "ready-made" traffic. The writer will endeavour to collate the best opinions and sum them up in a convenient form for reference.

Width of Formation.

For the purposes of these articles it may be assumed that the work of the permanent-way engineer commences where that of the constructing engineer leaves off, viz. :—at the formation which is the top of an embankment or the bottom of a cutting, rammed, consolidated and levelled off from the centre-line to either side. On most lines this is done at an angle of about 1 in 30—like a flat table—the object being to throw off the rain which passes through the ballast and allow it to drain into the side-ditches and take the fine dust with it. The formation being once thoroughly consolidated by time and traffic, engineers do not like it to be disturbed, and when the cross-sleepers were substituted for the longitudinal baulks on the Great Western Railway, particular care was taken not to disturb the hard bed on which the baulks had rested.



DRAINS.—The pipes to be laid with open joints, which must be carefully cleaned out before the trench is filled with dry rubble. The drains must be laid with top of the pipe 12 inches below formation where the drain follows the gradient of the cutting. In special cases 18 inches must be taken as the minimum depth from formation to top of pipe.

Fig. 1.—Ballasting for straight Line.

The width of the formation varies on different lines. If Fig. 1 be referred to, and which gives the details of the practice of the Midland Railway, it will be seen that in a cutting the formation extends between the foot of the slopes on each side, all of which are levelled, and this

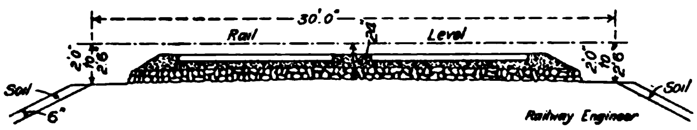


Fig. 2.

allows a space of about 4ft. between the end of the ballast and the slope. On an embankment the formation extends to about 4ft. beyond the end of the ballast.

The standard widths for double lines for their formation adopted by a few typical companies are given below :—

Railway		Embankment		Cutting	
L. and North Western		30	0	30	0
Midland		33	0	30	0
Great Northern		30	0	28	0
Pennsylvania	Double	32	8½	36	8½
,,	Single	19	8½	23	8½
Phila'. and Reading	Double	31	6	33	0
,, ,,	Single	18	6	20	0
Wabash	Double	31	0	41	0
,,	Single	18	0	28	0
Illinois Central	Double	34	0	46	6
,, ,,	Single	20	0	32	6
Lehigh Valley	Double	32	0	32	0
,, ,,	Single	19	0	19	0

The details of these and other companies' Permanent Way will be illustrated, but in the meantime it may be remarked that the abnormal width for a cutting on the Illinois Central Railroad is due to their having a space of no less than 8ft. 6ins. from the toe of the ballast to the bank. The measurement given for the Wabash and the I.C. Railroad are for their best roads. For lines of less important traffic these dimensions are modified.

Bottom Ballast.

On the formation is then laid, by hand, the Bottom Ballast, which consists of large pieces of stone, generally not less than 3ins. cube nor more than 9 to 12ins. cube. But these sizes will depend somewhat on the kind of stone which is convenient, or at a reasonable cost, available. The depth of the bottom ballast is generally about 12ins. From Fig. 2 it will be observed that on the London and North-Western Railway it is 2ft. in the middle from the bottom of the bottom ballast to rail level, and from 2ft. to 2ft. 6ins. at the sides, and is composed of hard stone, hand-packed.

Fig. 1 shows that the bottom ballast of the Midland Railway is 9in. deep, except in cuttings on the straight. It is of stone or slag broken to pass a ring 9ins. diameter, but not to pass a ring 3ins. diameter. It is placed by hand and the depth from rail level to the bottom of the bottom ballast is 2ft. in all cases except in cuttings on the straight, where it is 1ft. 9ins. in the centre and 2ft. 3ins. at the drain.

Fig 3 gives details of the Great Northern Railway road bed. It will be observed that the formation falls from the centre line to the edge. The centre line is 2ins. above the average formation level and the sides are 2ins. below. The bottom ballast is 8ins. deep, and formed of stone or slag not more than 6ins. on any face. The depth from rail level to the bottom of the bottom ballast is 1ft. 10ins. in the centre and gradually increases to a depth of 2ft. 2ins. On a curve the depth is increased to 2ft. 4½ ins. on the outside.

In cuttings the bottom ballast is spread over the whole width of the formation. On embankments on the London and North-Western Railway it is spread for a width of 26ft.; on the Midland Railway 24ft. 8ins.; and on the Great Northern of 25ft. 3ins.

Top Ballast.

On the foundation made by the bottom ballast, the top ballast is laid at a depth of from 6in. to 12in. On the

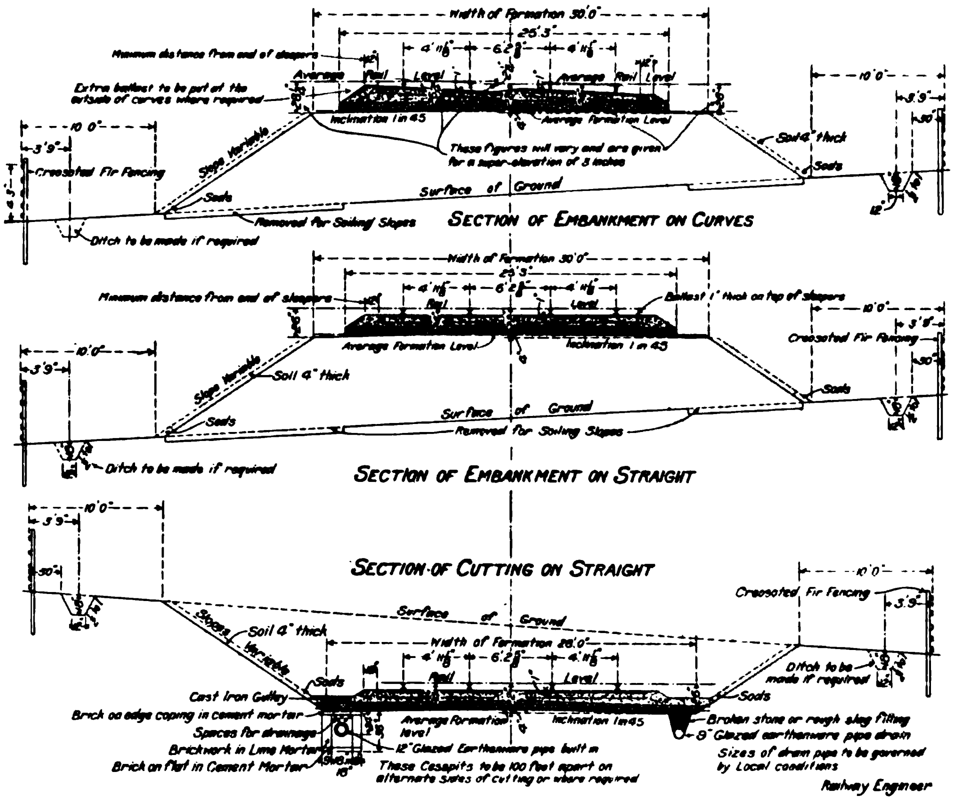


Fig. 3.

London and North-Western Railway it has to be of a quality equal to the best road metal. The pieces must be capable of being passed through a ring 2ins. diameter inside; 90 per cent. must pass through a ring 1½ins. diameter inside, but not through a ring ½in. internal diameter. Not more than 1 per cent. must be capable of being passed through a sieve ½in. mesh. Granite or blast furnace slag are to be used for top ballast. On the Midland Railway the top ballast is of stone or slag, broken to pass a ring 2¼ins. in diameter and not to pass a ring ¾in. diameter.

On the Great Northern Railway the top ballast is of screened gravel or fine broken slag from 1½ins. to ¾in. in size.

Most British companies level the top ballast with the top of the sleeper, but the Great Northern cover the sleeper for a depth of 1in. A foot of ballast is placed at the outside end of the sleepers on most, if not all, lines, and the space between the inner ends is filled level with the top of the sleeper.

As to America, the *Manual of Recommended Practice* of the American Railway Engineering and Maintenance of Way Association says :—

"While there is great variation in the qualities of the different natural materials for ballast, the choice of these qualities is not usually left to the engineer but has been made already by nature, and all that is left to decide is what is most available or most expedient. This each one must decide for himself in the light of his own circumstances. The question of finance may be a ruling consideration or there may be but one thing to be had, and he must take that or nothing. In the case of crushed rock, however, the process of manufacture being under control, it is practicable to make the product conform to specifications."

The specifications as to stone ballast recommended by the Association are (*a*) Stone shall be durable enough to resist the disintegrating influences of the climate where it is used. (*b*) It shall be hard enough to prevent pulverizing under the treatment to which it is subjected. (*c*) It shall break in angular pieces when crushed. (*d*) The maximum size of ballast shall not exceed pieces which will pass through a screen having 2in. holes. (*e*) The minimum size shall not pass through a screen having ¾in. holes. The specifications recommended for gravel, cinders and burnt clay are as follows :—

Gravel should be screened or washed where prevention of dust is an object, but this need not be done where the character of traffic is such that dust is not particularly objectionable. It is recommended that gravel be screened or washed where the proportion of sand or clay exceeds 50 per cent. The minimum size should be such as is retained on screens of 12 meshes per inch. By this is meant the size pebble that would be retained in a thorough, careful test. The uses of cinders as ballast is recommended for the following situations: On branch lines with a light traffic; on sidings and yard tracks near point of production; as sub-ballast in wet, spongy places; in cuts on fills; as sub-ballast on new works

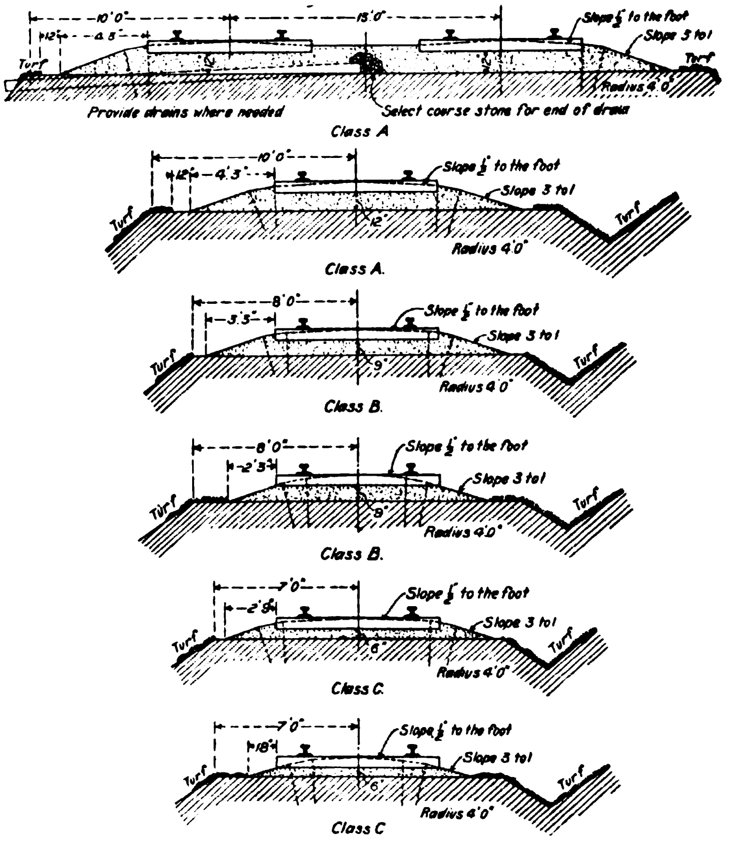


Fig. 4.

where dumps are settling, and at places where the track heaves from frost. It is recommended that provision be made for wetting down cinders immediately after being drawn. Burnt clay should be black gumbo or other suitable clay, free from sand or silt. The suitability of the material should be determined by thorough testing in a small test kiln before establishing a ballast kiln. The material should be burned hard and thoroughly. The fuel used should be fresh and clean enough to burn with a clean fire. It is important that a sufficient supply be kept on hand to prevent interruption of the process of burning. Burning should be done under the supervision of an experienced and competent burner. Ballast should be allowed to cool before it is loaded out of the pit. Absorption by water should not exceed 15 per cent. by weight.

Fig. 4 shows the recommended practice of the Engineering and Maintenance of Way Association for three different classes of road. Class *A* is for use only on the firmest, most substantial and well-drained road-beds.

(*To be continued.*)

50ft. Corridor Passenger Brake Van; Caledonian R.

We illustrate one of six 50ft. Corridor Brake-Vans for passenger trains recently built to the designs of Mr. J. F. McIntosh, locomotive carriage and wagon superintendent of the Caledonian R., at the company's works at St. Rollox, Glasgow.

These Brake-Vans are 6ins. wider and 2ft. longer than any previously constructed for the company. Their bodies are 50ft. long, 9ft. wide at waist, and 7ft. 9½in. high from floor to ceiling.

We shall illustrate these Vans more completely at a later date, but in the meantime the following particulars, which Mr. McIntosh has kindly supplied us with, will be useful:—

The cross section of body (as well as the side elevation both as regards panelling and painting) is similar to that of the 65ft. "Grampian" Corridor Coaches, which this new class of Van will match and work with when required.

The floor for a distance of 20ft. from each end slopes towards the longitudinal centre, along which is a 2 by 1 gutter, communicating with three drain pipes.

There are four double doors on either side, and a central door for the guard opening inwards. In the guard's enclosure, which is partitioned with glazed screen, are two side seats, under which are placed storage heaters and a locker for valuables.

The electric light is supplied by an axle-driven dynamo and accumulators, there being six double roof lights, two guard's lights and two side lights.

The internal fittings include electric bells, cycle racks and straps, and "Havock" ventilators. The Westinghouse, vacuum, automatic and hand brakes are fitted.

The underframe is of composite construction. The sidesoles, headstocks, bogie and centre cross-bearers are of steel channels $9 \times 3\frac{1}{2} \times 3\frac{1}{2} \times \frac{1}{2}$, and the intermediate cross-bearers are steel angles $3 \times 3 \times \frac{1}{2}$. The cross-bearer from which the dynamo for lighting is suspended has its lower member of $4\frac{1}{2} \times 2\frac{1}{2} \times \frac{1}{2}$ section. The longitudinals and diagonals at headstock are of oak.

The four-wheeled bogie frames are of pressed steel. The wheels are 3ft. 9in. diam., and have steel centres. The journals are $9\frac{1}{8} \times 4$. The axle-box bushes are of gunmetal, lined with white metal. Wheel-base of bogies 8ft. and of the van 42ft. 6in.

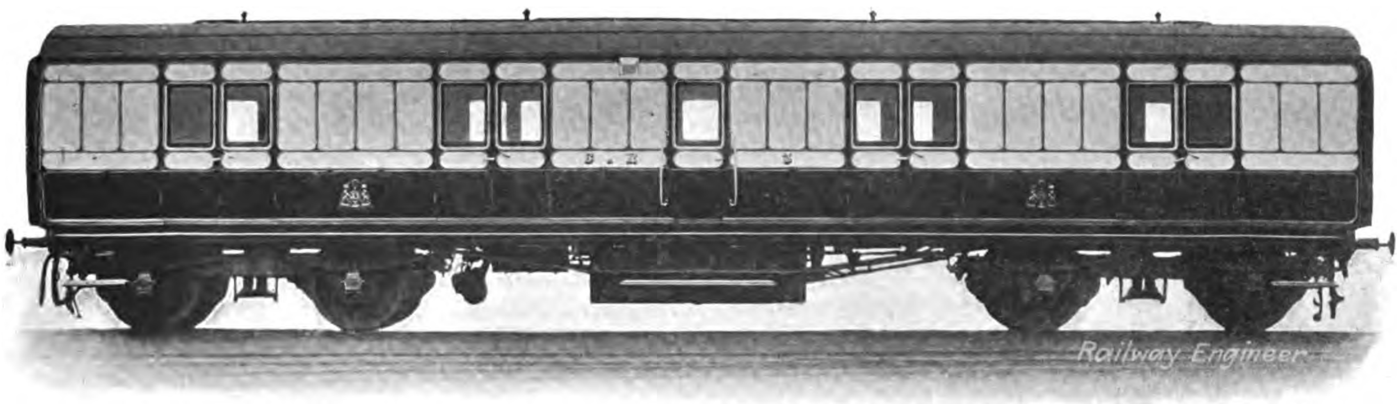
Tare of Van, 24½ tons.

Distribution of Current to Trains on Electric Railways.—VII.*

The Impossibility of Track Conductors for Two and Three Phase Working, except for the Return.

It may be as well to consider the reasons why the use of track conductors for two and three phase working is impossible. One reason has been given above, in connection with single phase working. As explained, single, two and three phase working is employed, principally because it enables the pressure to be raised and currents to be distributed easily and conveniently at high pressures. But with high pressures the question of insulation becomes a more and more difficult one, and it would be, with present appliances and under present conditions, practically impossible to provide sufficient insulation, with the high pressures that have been named, if even a single phase system of track conductors were employed. With two or three phase track conductors the difficulty becomes very much increased, because the space available being strictly limited, and there

*No. I. of this series appeared in the *Railway Engineer*, August, 1907; No. II. in October, 1907; No. III. in December, 1907; No. IV. in February, 1908; No. V. in April, 1908; No. VI. in June, 1908.



50ft. Corridor Passenger Brake Van; Caledonian Railway.

being no means of increasing it, in the great majority of cases, in railway working, the space available for insulation has to be divided up into two or three, as the case may be. In addition to this, the cases of sidings, crossovers, switches, etc., even if the other difficulties could be overcome, would render it absolutely impracticable. With continuous currents, and 500 volts, the matter of switches and crossings is dealt with with comparative ease, but when it is remembered that with two and three phase currents each of the phases must be switched, quite independently of the others, and that the switching must be so arranged that each phase is well insulated from the others, and from the earth, in every position, and is so guarded that dirt, wet and the numerous things which happen on a railway cannot materially reduce the insulation, the difficulty of the problem will be seen.

On the other hand, with overhead conductors, though the problem is by no means so simple as it may appear to outsiders, it is comparatively simple, compared to the problem involved when track conductors are employed. It will be understood that in all overhead conductor work the conductor has to follow the train, or the tram, wherever it is required to go, and where switches or turnouts are fixed in the tracks, switches and turnouts have to be arranged in the overhead conductors, so that the trolley collector can follow the variations in the direction of the track. This leads, of course, to a certain amount of complication, wherever two overhead conductors are employed, and still more where three are employed. It will be remembered that in the arrangement of three phase working, with two overhead conductors, and the track or a conductor on the track for the third phase, the full pressure of the system, 3,000 volts or 6,000 volts, exists between the two overhead conductors, and between each of the overhead conductors and the track, and therefore all the switches, turnouts, etc., of the overhead conductors must be arranged so that the insulation between the two conductors is always sufficient to stand the highest pressure that may be met with in all positions of the switch.

A point that is of importance had better be mentioned here. The pressure between the conductors of the three phase system, or between the conductor and the ground of a single phase system, is not the highest pressure to which the insulation of the system may be subject. The induction that has been mentioned in a previous portion of the articles acts in a somewhat peculiar manner to produce a very large increase of pressure when the system is relieved of a large portion of the load. The action referred to is what Faraday called the extra current. It may be explained as follows. When a pressure is applied to a conductor the current does not immediately pass through the whole of the conductor. It does not pass through the conductor until an electro magnetic field has been created round the conductor throughout its length. When the pressure is removed the energy employed in creating this magnetic field returns to the conductor, and creates, momentarily, a very high pressure. This is the simplest case. The same thing occurs to a smaller extent with a sudden decrease of load. This is the reason for the peculiar feature in connection with alternating currents that has been mentioned in a previous article, the power factor. As the strengths of alternating currents are constantly changing, induction is constantly taking place in the coils carrying the currents. But it may be taken that the same action is met with when a large portion of the load is removed as with the simple single current referred to above, and that the insulators employed, and the insulating system, whatever it may be, must be able to stand the momentarily increased pressures, and in particular to withstand the greatly increased ability to spark through them.

The insulation provided for conductors carrying electric currents is subject to two strains There is a constant leakage of current through the insulating material in the case of a cable, and through the insulating substance of an insulator in the case of a naked conductor, and also over the surface of the insulator in the case of the naked conductor. In addition to this, the insulator, whatever its form, is subject to sparking through its substance. The extreme form of the spark is one we are all familiar with, though not so much in this country as in tropical and sub-tropical countries, viz., the lightning flash. Every substance opposes a certain resistance to the passage of a spark through it, or, put in another way, there is a certain breakdown pressure for every substance, at which a spark will pass through it. When a spark passes through the insulating material of a cable the insulation of the cable is destroyed, and the cable is rendered useless until that portion is cut out. The insulation of the system therefore must be so arranged that in every position of the switch, and under all conditions of working, the leakage current is small, and the ability to resist sparking is sufficient to meet the very highest induced pressure that may arrive.

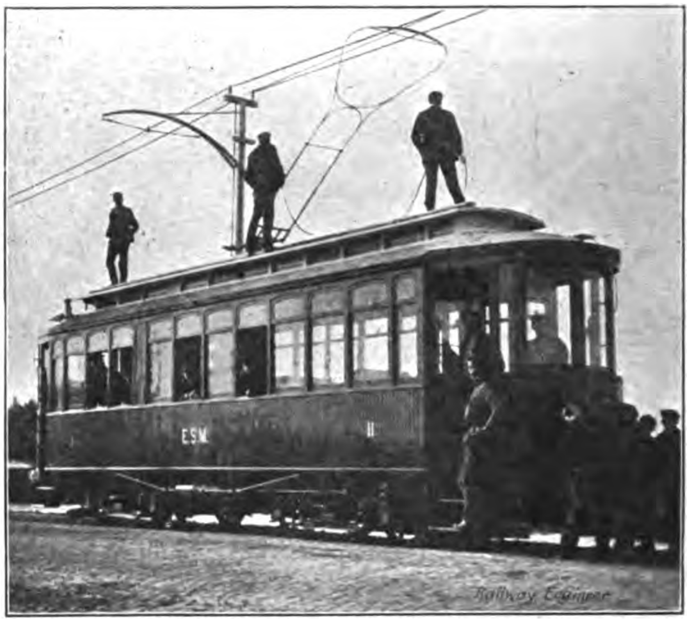


Fig. 30.—Example of the bow collector used on the Continent. The illustration is of a car on the Amsterdam-Haarlem Railway.

There is not space in these articles to detail the arrangements for switching the trolley conductors. It may be taken, however, that they closely follow the switching arrangements of track rails. When a train has to leave one track for another the overhead trolley wire is switched, so that the collector carried by the train follows the trolley wire over the new track on which the train is running and there finds the supply of current, just as in the track it has just left. And this applies to continuous current, single phase,

two phase and three phase, bearing in mind, of course, that where there are two trolley wires overhead both have to be switched when required.

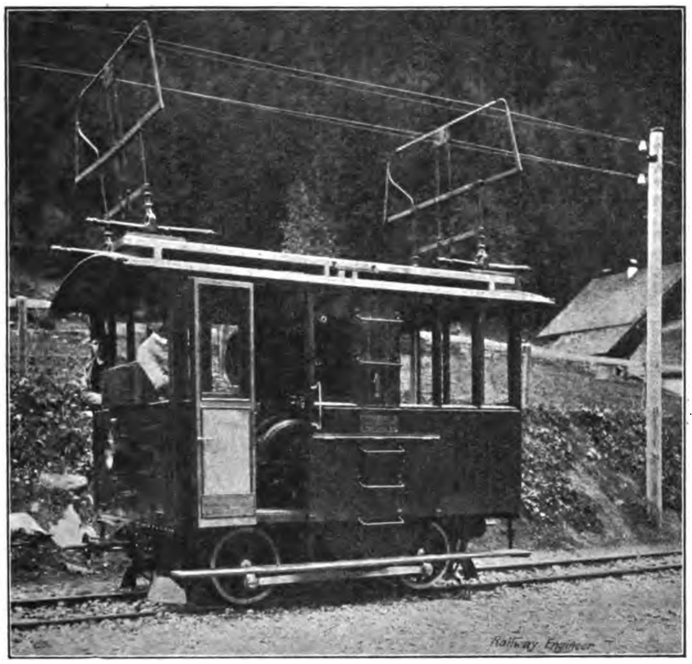


Fig. 31.—Electric Motor car used on some of the Swiss Railways. The collectors can be adjusted to any height and any angle.

The Support of the Trolley Wires for Two and Three Phase Services.

The introduction of two trolley wires overhead brings additional factors into the problem involved in delivering the current from the overhead conductor to the train. Where there is one conductor only overhead the problem is comparatively simple. Any collecting device that will follow the overhead wire, under all conditions, round curves, up and down hill, etc., will answer the purpose. With main line service and with fast train service the question of speed has also to be taken into account. In order that the current

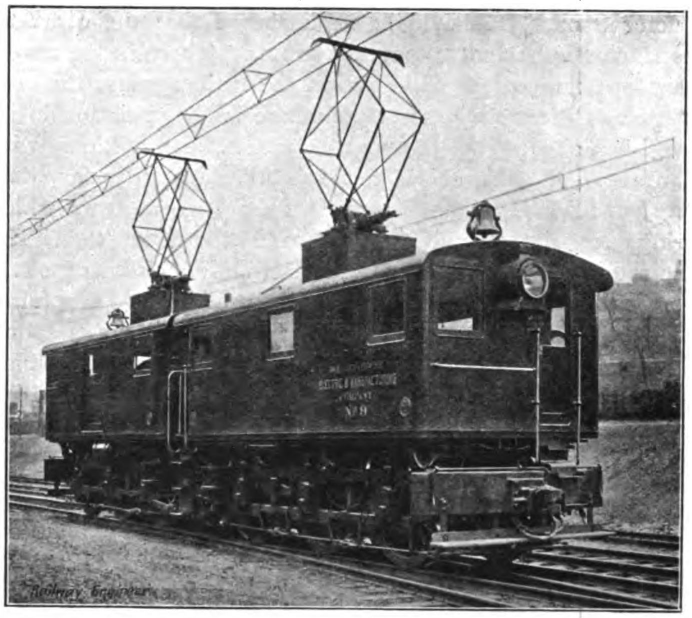


Fig. 32.—Westinghouse-Baldwin Electric Locomotive for heavy goods traffic with Pantograph collectors. The overhead conductors have also the Westinghouse double catenary suspension.

shall pass from the overhead conductor to the collecting device on the train, and thence to the motor, etc., it is necessary that a firm contact shall be made between the collector and the overhead conductor, and that this firm contact shall be maintained under all the conditions of the service. With the comparatively low speeds of electric town tramways, there is no difficulty in maintaining firm contact be-

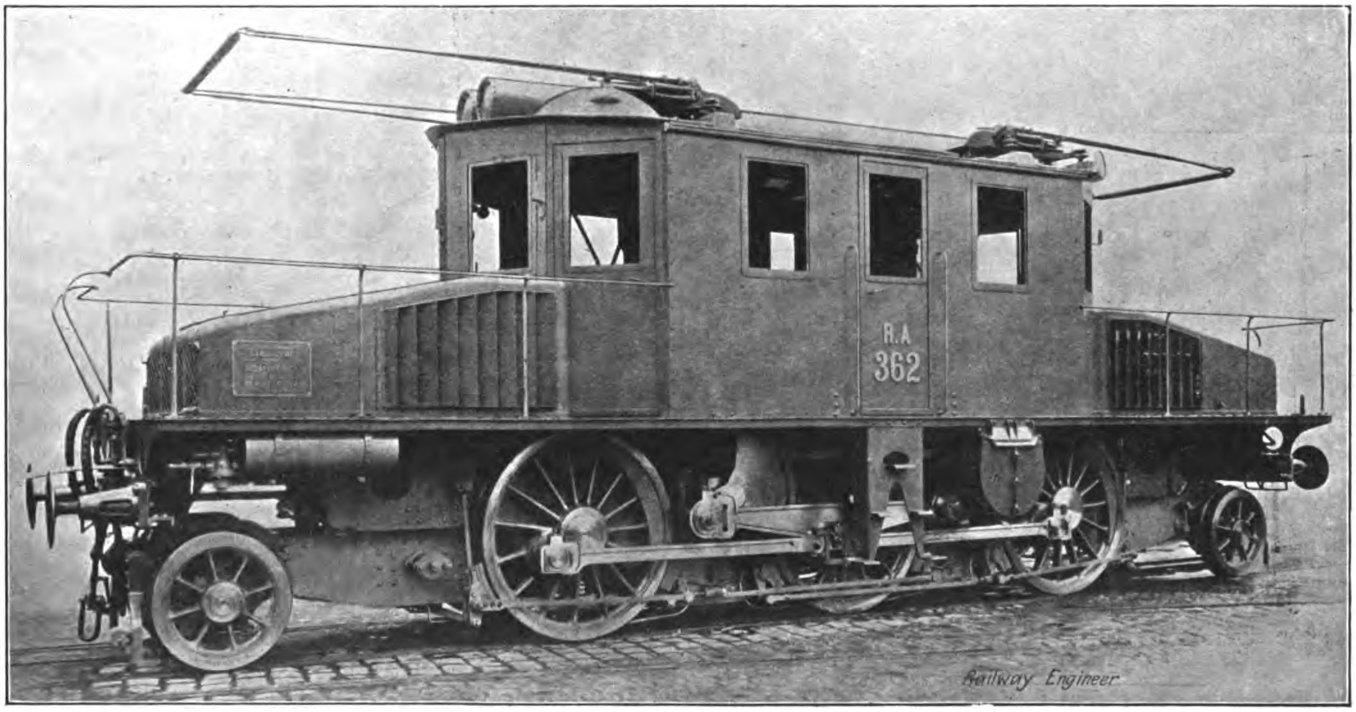


Fig. 33.—Three Phase Electric Locomotive made by Messrs. Ganz, of Buda-Pesth. The rectangular collectors are shown lying down. When in use they are raised to any desired angle above the car.

tween the trolley wire and the wheel at the end of the trolley pole, with comparatively simple conditions of construction. But with the fast speeds of main line and suburban trains the contact is not so easily maintained, unless great care is taken with the collecting apparatus and the overhead conductor itself. It should be remembered that the overhead conductor is subject to several strains. There is the necessary pressure of the collector on the train against the conductor as the train passes, and there is the variation in its length produced by the expansion and contractions with variations of atmospheric temperature. In particular, during some winters there is a very special snowstorm, which brings very great trouble upon all overhead conductors. The snowstorm in question comes to us usually in front of a stiff northerly wind. It is a very cold wind, and it is fairly charged with moisture, which it delivers in the form of snow. But the striking feature about the storm is, the snow which settles, say, on telegraph wires, trolley wires, etc., and which is melted by the impact of the snow driven by the force of the wind against the wires, instantly freezes, the frozen mass forming a bed for a further deposit of snow, the result being that the wire quickly acquires a shell of ice, sometimes as much as an inch in diameter. The contractile force of this mass of snow, added to its weight, and the resistance it offers to the wind which has deposited it, all tend to bring a very heavy strain indeed upon the wires. Fortunately this storm only comes once every few years, but when it does come the damage it does to telegraph and telephone wires is enormous. In one year the United Telephone Co. of those days suffered damage to the extent of £30,000 to its overhead wires in London, and in the same year the telegraph wires by the side of the Great Western R. were also damaged to the extent of several thousands of pounds. This is, of course, the extreme case, but contractions in cold winters, and in cold districts, must be provided for, and expansions in hot weather also. Further, when there are two overhead conductors the relative position of the two must be maintained uniform, so that the collectors upon the train can always make sure of obtaining their current.

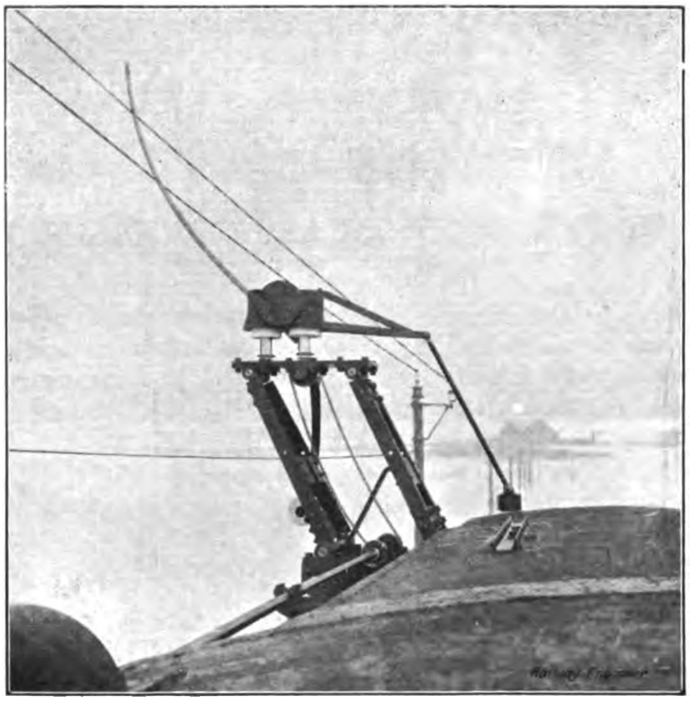


Fig. 34.—Collector used by The Oerlikon Co.'s, arranged to collect from wires by the side of the track.

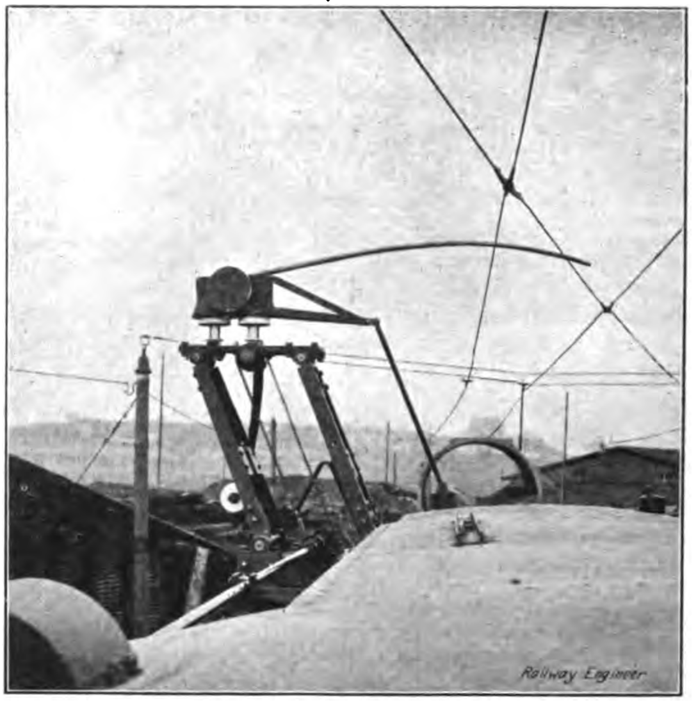


Fig. 35.—Collector used by The Oerlikon Co.'s, arranged horizontally under the overhead conductor.

The Catenary System.

The above requirements have led to the development of what is called the Catenary system. In place of, and in some cases in addition to the arrangement described in a previous article, of suspending steel wires across the track, what is called a messenger wire is suspended over the track, parallel with and above the trolley wire. The messenger wire is arranged mechanically to support the trolley wire, under all conditions, at one level. The messenger wire is itself insulated, and the trolley wire is suspended from it by hangers of varying lengths, a few feet apart, the distance between the hangers varying with the conditions. This is what is called the single Catenary system. The Westinghouse Co. have also developed a double Catenary system, in which there are two messenger wires, usually of stranded steel, stretched above the position of the trolley wire, and the latter is suspended below and between the two messengers, the three wires forming an acute angled triangle. For two overhead conductors two steel messengers or two pairs of steel messengers are suspended over each track, and from them the two trolley wires are hung, as described.

The development of the Catenary system of suspension has led to its adoption for single phase wires in place of the simple system described in a previous article. In some railways it is arranged to keep the trolley wires stretched tight by a balance weight, the wire, as before, being suspended from the messenger by hangers.

Collecting Devices.

The collecting devices employed for train service with overhead conductors have also been developed. Quite early in the history of electric traction the trolley pole and wheel was superseded on the Continent by the bow form of collector, consisting of a rectangle of wire carried above the

car and arranged to swing to and fro, as required by the movement of the car, without the necessity of turning it round, as is required with the fish pole trolley. The rectangular bow conductor has been developed in various ways, forms of which are shown in figs. 30-35. The great object in all forms, it will be understood, is to provide a firm contact between the collector and the trolley wire, and an easy transmission of the current to the regulating apparatus and motors on the car. Any inequalities in the contact leads to sparking, and at the high pressures carried the sparking would have a very serious effect upon the life of the trolley wire.

Delivery of Current to the Trolley Wire with Two and Three Phase Currents.

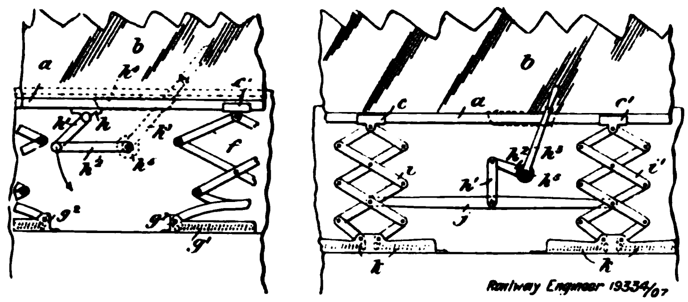
The current is delivered to the trolley wires with two and three phase currents, whether there are one, two or three overhead conductors, in exactly the same manner as with single phase currents. The current is generated at any convenient spot, and feeder cables are carried from the generating station to distributing points, where they are transformed to the working pressure, at which they are delivered to the trolley wires by the usual feeder cables. The tendency is to gradually increase the generating pressure, just as it is to increase the trolley wire presure. The generating pressure is, in fact, largely the dominant factor in the problem of the distribution of electric currents to railway trains. The higher the pressure the greater the distance over which currents can be economically delivered, and the distance increases, as already explained, as the square of the pressure. It follows, therefore, that providing the pressure can be made high enough, the generating station can be where for other reasons it is most economical, as where coal is cheap, water abundant, and the problem of the dumping of ashes is not troublesome. Generating pressures of 20,000 volts for railway work are now common, and, as in America, pressures of 80,000 volts are being employed for carrying the power from waterfalls, or the great rivers, to industrial centres, it is more than probable that these pressures will be adopted for railway work as time goes on.

Recent Patents Relating to Railways.

THESE abridgments of recently published specifications are specially compiled for this review by Messrs. Wheatley and Mackenzie, Chartered Patent Agents, 40, Chancery Lane, W.C., from whom copies of specifications can be obtained at an uniform price of 8*d*. each.

Raising Carriage Windows. *19,334. 28th August, 1907. W. E. Laycock, Victoria Works, Millhouses, Sheffield.*

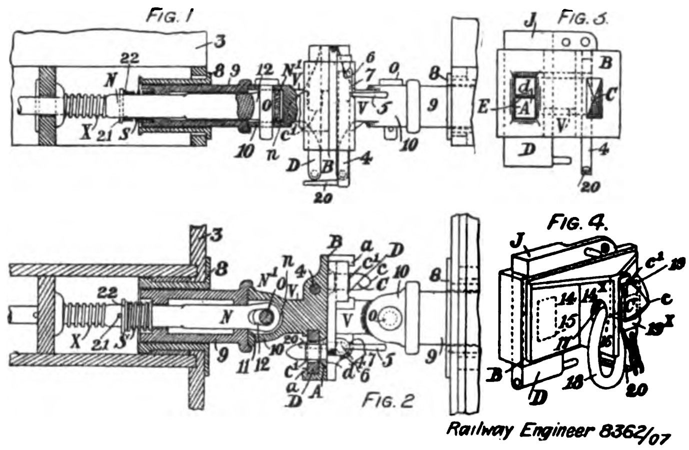
This invention is applicable to windows in which the frame containing the glass or the glass itself where no frame is employed, is of great width, such for example as those employed in saloons or restaurant cars. Near its ends the frame or glass is supported by lazy tongs, such as *e f* or *i i*. The lower ends of the tongs have secured to them springs g g^1, or are contained within a suitable casing, such as g^2, and connected to the lazy tongs, which are pivotally secured to the casing. The springs, shown by dotted lines in the drawings, are arranged so that they are extended and have a tendency to urge the tongs upwards, thus counterbalancing the weight of the glass *b*. By this means the effort to raise the window is reduced to a minimum. Also secured to the frame *a* is a third bracket *h* to which is pivotally connected one end of a link h^1 the lower end of said link being connected to an arm h^2 operated by a hand lever h^3 disposed upon the outside of the recess containing the lazy tongs and for which a guide, such as h^4 shown in dotted lines, may be provided. The arm h^2 and the lever h^3 are preferably connected to the members of a ball or other like clutch of known form and indicated by h^5, so that the movement of the arm cannot take place other than by operating the lever h^3. By this means the accidental movement of the window



is prevented. Instead of connecting the link h^1 to the window, it may be connected to a crossbar *j* joining the lazy tongs. (*Accepted 23rd April*, 1908.

Central Buffers and Couplings. *8,362. 10th April, 1907. G. Johnston, 16, Balmoral Road, Fairfield, Liverpool.*

The buffer head V is provided with a flat face B having a bell mouthed rectangular hole right through it on one side of the centre line, and a drawhook C on the other side of the centre line. Verticle coupling bolts D engage the drawhooks C, and are raised to release the hooks by rods 4 provided with handles 5. In shunting operations the bolts D are prevented from falling down to engage the coupling hooks by turning the handles 5 of the rods 4 so as to rest on abutments 6. Each rod is provided at the bottom with a finger 20, which overruns and passes under the bottom end of the coupling bolt D of the adjacent buffer when two vehicles come together. Consequently if the handle 5 be raised, the upper end of the rod will lift one of the coupling bolts, while the projecting finger will lift the other coupling bolt. A guide box 8 is fixed in the headstock 3 of the vehicle through which a socket or sleeve 9 passes, the internal size of the socket forming an easy fit for the draw or buffing bar N to pass through. The front end N^1 of this draw bar N is semicircularly shaped to fit into a corresponding cavity in the rear end 10 of the buffer head V, and the draw bar end and buffer head are coupled together by a pivot pin O. The forward end of the socket or sleeve 9 is recessed at 11 or formed as a seat for the rear end of the buffer head V to abut against, and a spring S is provided on the draw bar, secured by a gib 21 and washer 22 in such a manner that



this spring pushes the socket or sleeve forcibly against the rear end of the buffer head V and holds the buffer normally in alignment with the draw bar N. The buffing force is communicated through the buffer head direct to the draw bar end and thence to a buffing spring or springs X, the hole 12 for the pivot pin O in the draw bar end being slotted to the rear to prevent any shearing strain upon the pin. The tractive force is received by the pivot pin O, draw bar N and draw spring or springs. The object of the spring S at the rear of the socket or sleeve 9 is to force the sleeve 9 tight against the rear of the buffer head V and keep it normally in alignment with the draw bar. If, however, the buffer be turned on its pivot pin, the sleeve 9 is depressed against its spring S, but the spring S restores the buffer into alignment again directly the force that turned the buffer is

removed. Furthermore, as the hole 12 for the pivot pin in the draw bar end is slotted to the rear, the buffer head is capable of movement in a vertical arc as well, so that if two vehicles on coming together are unequally loaded, the nose of the hook which is on the lower level, striking against the bottom edge of the bell-mouth A, will cause the buffer face to turn through a vertical arc, the slotted hole 12 and the shaping of the draw bar end permitting of this, thus the hook impinging against the adjacent bell-mouth, will bring the hook and bell-mouth of one buffer into alignment with the hook and bell-mouth of the other buffer, although the body of one of the buffers and its draw bar may be considerably below the other. The spring S abutting against the socket 9 does not take any part of the buffing force. The arrangement described allows of a true adjustment of the buffer faces when going round curves or when the vehicles are on an unequal plane. To enable the buffer to be coupled to a buffer of another type a block 14 is provided, having at one side of the centre line a hook 15 similar in shape to the drawhook C, and at the other side an opening 16. At the front this block has a flange 14^x with a hole 17 in it, in which there is a link 18, or instead of a link, the block can be furnished with a hook. (*Accepted 9th April*, 1908).

Fluid Pressure Brakes. *22,124. 7th October, 1907. The Westinghouse Brake Co., Ltd., 82, York Road, King's Cross, London. Communicated by The Westinghouse Air Brake Co., Pittsburg, Pennsylvania.*

This invention provides a double brake system in which the brake is automatically applied in case of emergency with greater pressure than in service applications. Two brake cylinders are provided, preferably of that type in which the small cylinder 35 is carried on the large piston 33 within the large cylinder 14 and contains the small piston 34 acting against the brake cylinder spring 36 and the rod 40. The large piston head 33 is provided with a circular rib or projection 38, which engages an annular gasket mounted in the large cylinder head and normally preserves a tight joint surrounding the port 37, which leads through the head into the small cylinder and registers with the inlet pipe connection 12 for supplying air in service applications. Any suitable form of manually controlled device may be employed for governing the supply of air to and its release from the pipe 12 leading to the small or primary brake cylinder, but such device may comprise an electric application valve device having a main valve casing 6, auxilliary valve casing 7 and electro-magnet 9, and an electric release valve casing 8 with its electro-magnet 10, the wires and circuits for all of the magnets on all the cars being extended through the train to a switch at the forward end of the head car or any other convenient location for operation by the motorman in charge. A supply pipe 11 leads from the reservoir 5. or source of air pressure, to the electric application device, which comprises a main valve 20 operated by a piston 21 mounted in chamber 24 and controlling a port opening from supply pipe 11 to pipe 12 leading to the primary brake cylinder. The piston 21 is normally balanced as to fluid pressure by leakage of air around or through the piston to chamber 24, the valve being normally seated by a spring 23 and the additional area exposed to fluid pressure on the back of the piston. A port 25 leads from the piston chamber 24 to the regulating valve 27 which controls the release of air from said piston chamber to the outlet port 26, which may communicate with the brake cylinder pipe 12, or otherwise. The electric release valve body 8 may, for convenience, be mounted on the main valve casing 6, and a port 22 leads from the brake cylinder pipe 12 to the release valve 28, which is operated by the magnet 10 to control the exhaust from the primary brake cylinder to the atmosphere through exhaust port 29. When the system is duly charged with air under pressure and the application magnet 9 is energised in the usual way for making a service application of the brakes, the small auxiliary valve 27 is pushed from its seat, thereby releasing air from piston chamber 24, whereupon the greater pressure acting on the opposite side of piston 21 raises the valve 20 and opens the supply port to pipe 12 and the primary brake cylinder. When the switch is turned to break the circuit of the magnet 9 the valve 27 closes and the pressure quickly equalises upon opposite sides of piston 21, whereupon the spring acts to move the valve 20 to its seat and close the supply port. By the use of a small auxiliary valve for governing the pressure on the piston actuating the main valve a small magnet may be employed to control the device, while at the same time a large port may be quickly opened for supplying air to the brake cylinder in sufficient volume to charge the same with the desired rapidity. The brake cylinder pressure may be graded down, or released, by energising the magnet 10 and operating the release valve 28 in the usual way. In order to operate the brakes in emergencies, either automatically by the pulling apart of the cars in the train or manually by the motorman or conductor from any point in the train, an emergency valve device is provided for supplying air to two brake cylinders or to a single larger brake cylinder than is used in service applications for the purpose of giving a greater braking power in case of emergency. As shown, this emergency valve device comprises a standard quick action triple valve 15 of the Westinghouse type, connected in the usual manner to the automatic train line pipe 16, which extends through the train, and through which the wave of reduction in air pressure necessary for operating the brakes in emergency may be made, either automatically by a break-in-two of the train, or by the opening of a brake valve or conductor's valve at any point in the train line. The valve chamber of the triple valve communicates by pipe 13 with the reservoir 5 and the brake cylinder port 32 leads to the large brake cylinder 14. In order to prevent an excessive braking pressure in the large cylinder, and to provide for controlling the pressure therein according to the speed of the vehicle, a blow-down valve device 17 may be connected to the brake cylinder and governed by an electro-magnet 18, the supply of current to which is furnished by an electric generator 19 driven by the axle or momentum of the vehicle. The valve 30 controls the blow-down of the brake cylinder pressure to the atmosphere through the outlet port 31 and is normally held to its seat by means of a spring 39 of the desired tension. Sand is automatically applied to the rails at each emergency application by a sanding device connected by a pipe with the emergency cylinder. (*Accepted 23rd April*, 1908)).

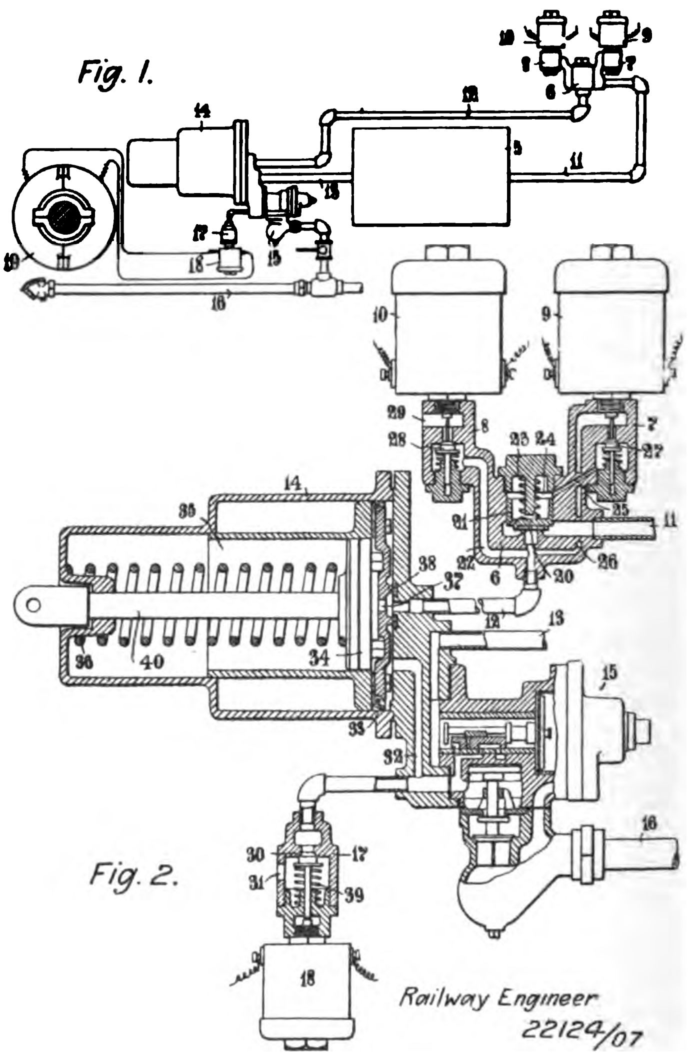


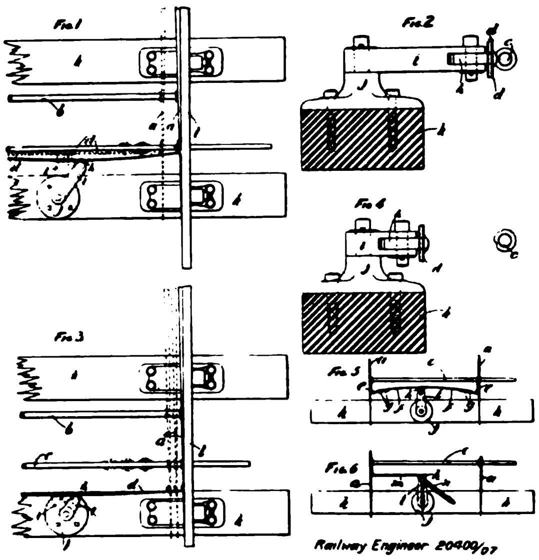
Fig. 1.

Fig. 2.

Permanent Way Switches. *20,400. 13th September, 1907. R. Bruce, 147, Garrioch Road, Maryhill, Glasgow.*

The switches are fitted with a spring bar *d* by which they are either automatically returned to the normal position after being operated, or are securely held in position at either side. This spring bar may be made in sections after the manner of a carriage spring, or it may be made in three sections, *e*, *e*, *f*, secured together by bolts *g* passing through slots, or oval holes to allow

of a slight amount of play, or it may be a simple bar, and is jointed near its central part by a lug *h* to the free end of a short levér *i* fulcrumed on a plate *j*, which is secured on the central part of the sleeper *k* carrying the rails *l* and switches *a*. For the purpose of returning the switches *a* to the normal position after being operated, this lever *i* is made of such a length that when the switches are operated it moves into a position almost but not quite parallel to the rails *l*, as shown in dotted lines, and in doing so bends the spring bar *d*. When the drawbar *c* is released the spring bar *d* forces back the lever *i* to its normal position, carrying the switches *a* with it. For the purpose of holding the switches in



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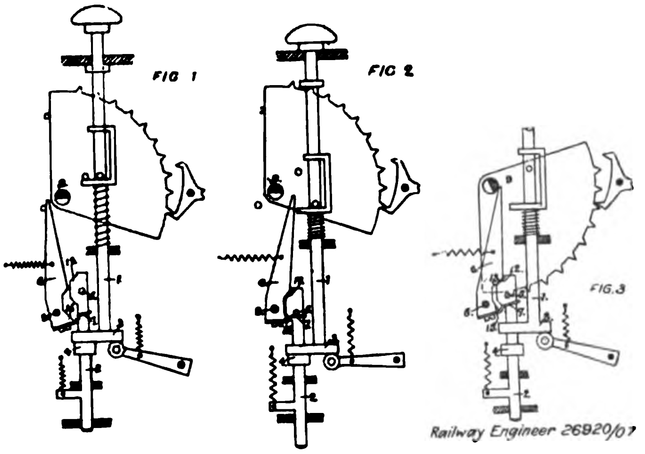
position at either side after being operated the lever *i* is made shorter, so that when the switches *a* are operated either way the end of the lever *i* passes the dead centre and is pressed down on either side of the centre by the spring bar *d* according as the switches *a* are moved, the different positions being shown in dotted lines. Instead of using a spring bar *d* the lever *i* may be jointed, as shown in Figure 6, by a connecting rod *m* to one of the switches *a* and a coiled or spiral spring *n* be connected to the lever end and to a point to one side of the lever *i* when it is desired to return it to the normal position, or, as shown in dotted lines, in line with it when it is in the position of being parallel to the rails when it is desired to hold the switches on either side after being set. (*Accepted 9th April*, 1908).

Electrical Locking for Signals. *26,920. 5th December, 1907. Siemens Brothers and Co., Ltd., 12, Queen Anne's Gate, Westminster. Communicated by Siemens and Halske, Actiengesellschaft, 3, Askanischer, Platz, Berlin, S.W.*

This invention relates to electrical block apparatus in which the pressing down of the plunger rod moves the locking lever into



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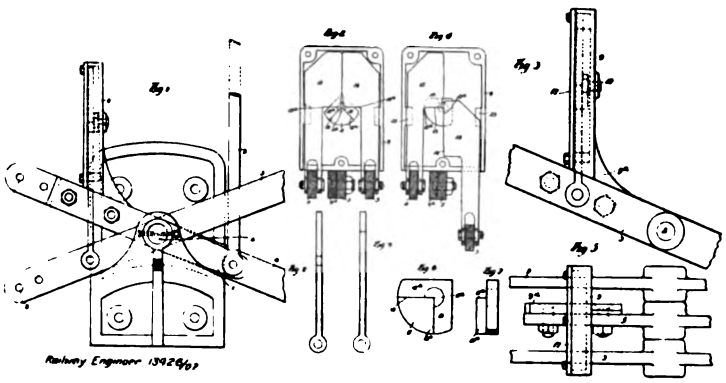
its locking position and consists in providing a flexible and a rigid projection on the locking lever and corresponding projections on the locking rod so arranged that the movement of the plunger rod is transmitted through the spring only, but in the event of the spring breaking down, then through the rigid projection. By depressing the plunger rod 1 the locking rod 2 is moved by means of the projections 3 and 4. A pin 5 is fixed to the rod 2, which when moving in a downward direction depresses the spring 7, which is fixed to the locking lever 6. The locking lever 6, which turns freely on the pin 8, therefore moves into the position shown in Fig. 2, its upper end passing the notch in the spindle 9 of the escapement segment. The projection 15 is thereby moved to the left hand or clockwise before it comes in contact with the projection 12 of the locking rod 2. If, however, the spring 7 is broken or otherwise becomes unserviceable the projection 15 will take up the function of the spring 7, in which case the movement of the locking lever will be effected, during the downward movement of the plunger rod, by the projection 12 coming into contact with the projection 15 of the locking lever. (*Accepted 23rd April*, 1908).

Slotting Signals. *13,426. 10th June, 1907. J. S. Moore, 95, Orsett Road, Grays, Essex.*

This invention relates to slotting or coaching apparatus for enabling two or more signalmen to jointly control a signal or signals. The intermediate lever 5, which together with the usual counterbalance levers 3, 4, is mounted on the signal post, carries a box or casing 9 arranged transversely of the levers 3, 4, 5. Mounted on a spindle or pivot 10 projecting through the rear of the box or casing 9 is a pawl or tumbler 11 which is in the form of a quadrant and which is rebated or cut away on its straight sides, the pawl being pivotted in the casing so that the apex 11^a coincides with its axis of rotation; this pawl 11 being cut away at 12 and 12^a provides shoulders 13 and 13^a at right angles to each other. Slides or tappets 14 and 15 pivotted respectively to the outside and inside counter-balance levers 3 and 4, the upper ends of these tappets being formed with inward lateral projections, thus providing shoulders 14^a, 15^a. Assuming two signal cabins,



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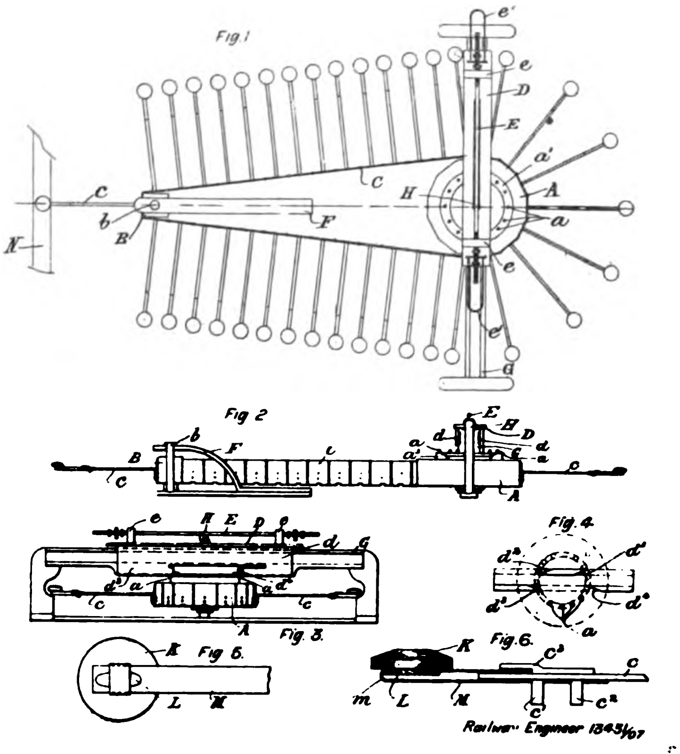
say A and B, and that the signalman in one of the cabins, say A, operates his lever, he will thereby operate one of the counterbalance levers, for instance, the outside lever 3, to the position shown in Figs. 1 and 4; by this movement of lever 3 the tappet or slide 14 is moved downwards in the casing 9 so that its shoulder 14^a, acting on the shoulder 13^a of the pawl or tumbler 11, rotates the latter into the position shown in Fig. 4, with its shoulder 13 engaging with, or in position to be engaged by, the shoulder 15^a of the tappet 15, but no movement is given to the intermediate lever 5 by this operation and consequently the signal arm is not lowered to the safety position. When, however, the signalman in cabin B operates his lever, which is connected to the inside counterbalance lever 4, this lever 4 will be moved to the position corresponding with that of the lever 3 shown in Figs. 1 and 4, so that the tappet 15 will be moved downwards, and owing to its engagement with the shoulder 13 of the pawl 11, the casing 9 will be moved downward, and consequently the lever 5 will be moved to the position corresponding to that of the levers 3 and 4, Figs. 1 and 4, whereby, through the operating connection 8 to the signal arm, the latter will be lowered to the safety position. With the counter-balance levers 3, 4 and lever 5 in the safety position the tappets 14, 15, and pawl 11 will again be in the position shown in Fig. 2, the casing 9 having been moved down so that its bottom is bearing on, or in position adjacent to, the levers 3 and 4, and the lever 5, and consequently the signal, are held in the safety position by the outer ends of the shoulders 14^a, 15^a of tappets 14 and 15 bearing on the shoulders 13^a and 13 respectively, of pawl 11. As soon as either signalman replaces his operating lever in the normal danger position the signal is returned to that position. (*Accepted 9th April*, 1908).

Fog Signalling Apparatus. *13,431. 10th June, 1907. H. Humphrey, 54, Market Place, Romford, Essex, and J. C. Pain, A. Pain and P. Pain, 121, Walworth Road, London.*

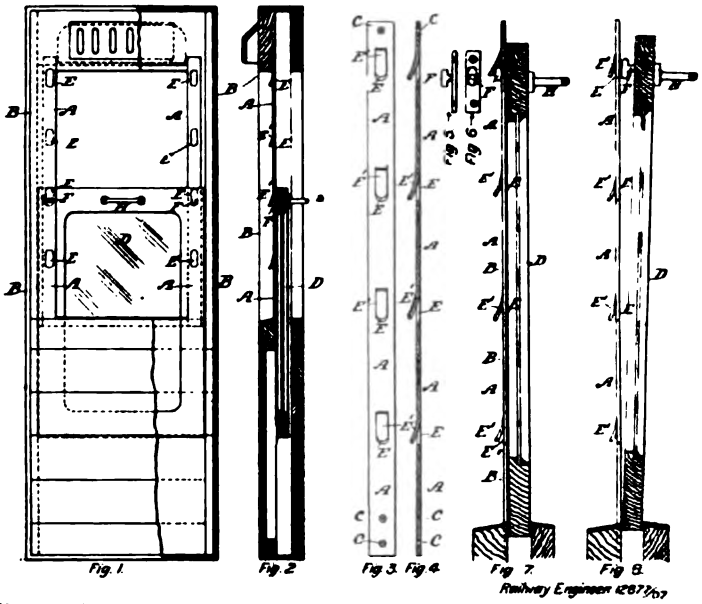
An apparatus for placing detonators on the line comprises, according to this invention, a gear wheel A journalled in a horizontal frame and a roller B of square cross section, journalled in a support, the wheel and roller carrying a belt C with links each equal in length to the length of one side of the roller. Arms carrying fog signals are attached to the links of the belt, which is actuated by a slide D, operated by the ordinary signal connections and having inclined surfaces adapted to engage studs *a* on the wheel A. If the machine be in the position shown, that is with a fog signal on the rail N and the slide moved over to one side, when the slide is moved to the other side, that is to say, suppose for instance it is attached to the signal wire and the signal is taken off, then the wheel A will be rotated by means of the inclined surface on the slide D acting on the roller studs *a a* a distance sufficient to move the fog signal off the line N forward a certain distance and to bring the next succeeding fog signal into a position near the rail N. In this position the line will be clear of fog signals, but if the slide be now moved back



again the wheel A will again be rotated in the same direction as before and the next fog signal moved into position on the rail. When a train passes over the fog signal while it is on the rail its weight causes the signal holder M to snap at the point *m* and thereby allows the lower limb of the holder to fall free from the arm C, which is thereby released and capable of being moved on, although the wheel of the carriage may remain on the fog signal. (*Accepted 2nd April*, 1908).

Raising Carriage Windows. *12,877. 4th June, 1907. E. R. Cooke, Norwood, Francis Road, Stetchford, near Birmingham.*

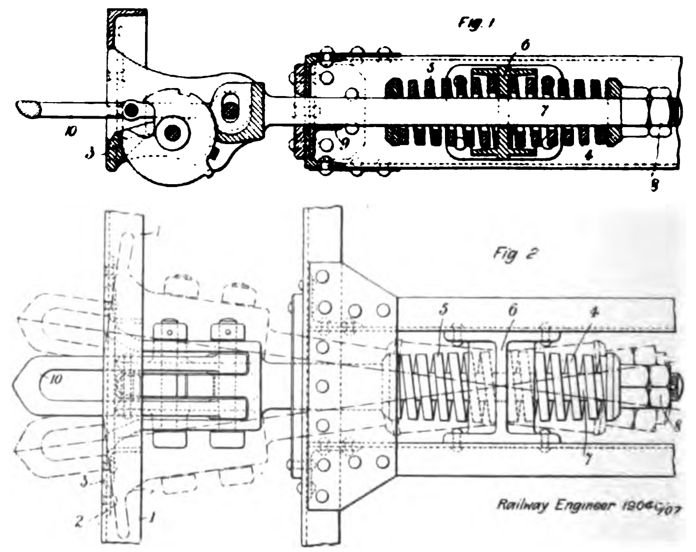
For the adjustment of carriage windows at different heights a vertical strip A of metal is attached to each side of the window frame B. Slots E are formed in the metal strips A at given distances apart vertically by cutting or stamping out the same in such a manner as to leave tongue pieces E¹, that is to say, the slots E are cut out on three sides only, so that the tongue pieces E¹ are not removed from the slots, but remain attached to the strips A, thus the tongues which are bent backwards form spring backs in the slots E. To the outside of each of the top corners of the sash are attached metal studs F with necks and heads; these studs engage the vertical slots E by falling into them according to the desired position of the window, either when closed or partly so. The object of the metal tongues E¹ at the back of the slots E is to assist the studs F by pressing spring-



like against them when manipulating the window. A handle H is provided for raising and lowering the window. (*Accepted 16th April*, 1908).

End Platforms for Vehicles. *19,046. 24th August, 1907. J. T. Jepson, Queen Anne Chambers, Tothill Street, Westminster.*

According to this invention, the platform buffer plate is combined with an automatic coupler, so mounted on the vehicle frame as to have sufficient lateral play to enable the platform buffer plate of one vehicle to remain parallel and in alignment with that of the contiguous vehicle under all conditions of curve, the coupler being connected to the vehicle frame through any preferred arrangement of draw, buffing and centralising springs, and being further supported by the vehicle frame so as to enable it to support the weight of the platform and its load without interfering with its lateral flexibility. The advantages of this arrangement are, in the first place that separate springs, plungers and pivots for supporting the platform buffer plate may be dispensed with. Secondly, that the faces of contiguous platform buffer plates are kept practically close for the full width of the platform under the heaviest drawbar pulls and under all conditions of curve. Thirdly,



the relative lateral movement of contiguous platform buffer plates is prevented. In the construction illustrated the platform buffer plate is formed as a horizontal frame 1, with downward extensions 2 rivetted to the buffer face 3 of the main coupler, and the combined arrangement of platform buffer plate and automatic coupler is supported by means of a system of draw buffing and centralising springs, which consists essentially of a pair of coil springs 4 and 5 disposed on either side of a central web 6, the extension of the buffer shank 7, which forms the draw bar, being passed through the buffing spring, the web and the oppositely disposed draw spring, the whole being screwed up by a nut 8 at the end of the draw bar so as to give initial compression. The weight

of the coupler and platform 1 with its load may be supported by means of a guide plate 9 fixed to the front member of the vehicle frame on which the flat underside of the shank 7 rests, the guide plate being of sufficient width to allow of the requisite lateral movement of the shank in coupling on and passing round curves as indicated in dotted lines in Fig 2. In applying the invention to vestibules, a similar arrangement of springs, but of lighter section, may be used at the top of the vehicle, the vestibule frame being provided, if required, with lateral projections or guides to secure alignment between contiguous frames. If actual close contact of the front faces of the platforms is required, this may be secured by interposing springs between the main coupler and the platform buffer plate, the travel of these springs being sufficient to take up any longitudinal slack which may occur in the coupler. (*Accepted 23rd April, 1908*).

COMPLETE SPECIFICATIONS ACCEPTED.

1907.

8362. Central buffers and couplings. Johnston.
8471A. Railway crossing barriers and signals therefor. Kessler and Jelich.
8974. Train-signalling apparatus for railways. Nimmo.
10091. Signalling devices for tramways, railways, and the like. Dewhurst.
12877. Means for raising, lowering, and adusting railway and other carriage windows and the like. Cooke.
13426. Apparatus for controlling railway signals and the like. Moore.
13431. Machine for placing fog signals of the detonator type on railway lines or the like. Humphrey, Pain, Pain and Pain.
13619. Railway wagons or other carriers for grain, coal, and the like, and loading and unloading the same. Brown.
17800. Device for stopping vehicles and trains at collisions or if the points are not in the correct position. De Halmy.
19046. Spring mounted platforms for railway vehicles and the like. Jepson.
19138. Railway rail joints. Reel.
19334. Apparatus for raising and sustaining the windows of railway and other carriages. Laycock.
19755. Railroad danger signals. Sughroue.
19975. Apparatus actuated by the passage of trains to control railway points or signals. Siemens Bros. and Co.
20400. Railway points. Bruce.
21045. Means for locking and unlocking railway carriage doors. Schofield.
22124. Fluid-pressure brakes for railway and like vehicles. Westinghouse Brake Co.
23833. Insulated railway rail joint. Wolhaupter.
24008. Railway and the like signalling apparatus. Lipka.
25076. Couplings for railway, tramway and other trains. Gellhorn
25299. Brake applying devices and warning or indicating devices for railway trains and the like. De Braam.
25301. Rail bond for rail joint circuits. Karns.
25596. Coupling apparatus for railway, tramway, and the like vehicles. Wren.
25832. Insulated railway rail joint. Wolhaupter.
26039. Railway rail joints. Bastel.
26614. Railway detonator or like sound signal apparatus. Mautsch.
26640. Railway rails and rail joints. Watkinson.
26920. Electrical locking apparatus for railway signals. Siemens Bros. and Co.
27658. Mounting of railway and tramway vehicles on their wheels. De Bange.
28126. Couplings for railway cars. Wehle.
28212. Electrical locking apparatus for railway signals. Hoffe and Jelfs.
28303. Signals for railways and the like. Herricht.
28612. Railway and like point controlling and detecting apparatus. Edmonds, and McKenzie and Holland Ltd.

1908.

1205. Safety catches for railway carriage doors and the like. Kaye.
3475. Metallic railway tie. Bowne.

Official Reports on Recent Accidents.

On **Chequerbent Incline, L. & N.W.R.** *On the 7th January. Lt.-Col. H. A. Yorke reports that:—*

The 7.30 a.m. passenger train from Kenyon to Bolton was being assisted up the incline by a bank engine in rear. The bank engine was allowed to drop behind and overtake the train twice. One passenger, 6 servants, and the guard were slightly injured.

The bank engine was a heavy 8-coupled 4-cylinder compound tender engine. It had recently been overhauled and repaired. The leading wheels of the front coach were derailed, the couplings between the second and third coaches broken, the latter coaches themselves buffer-locked, and the last vehicle, viz., the carriage truck, derailed and tilted up on end, one pair of wheels being separated from it. The bank engine and all the vehicles of the train were damaged.

Between Atherton Station and Chequerbent there is a steep incline of 1 in 30 for 1,579 yards, on which the accident occurred.

This accident is of an unusual character, and indicates grave mismanagement of the bank engine by driver Fairhurst.

The train, of only 5 vehicles, was a light one, and well within the capacity of the train engine to haul to the top of the bank, but owing to a carriage truck behind the rear van it was necessary, by the Co.'s rules, to put a bank engine in rear of it. It is not the custom to couple the bank engine to the train. The bank engine was a much more powerful engine than the train engine, and it probably required rather careful handling to prevent it from overrunning the train engine. Soon after the train had left Atherton, while driver Fairhurst (of the bank engine) was "notching up" the reversing lever, the regulator is said to have partially closed itself, with the result that the engine dropped behind the train. In order to re-open the regulator, which was rather stiff, Fairhurst (being a short man) went across to the fireman's side to push the regulator handle over instead of pulling it from his own side. It seems clear that he opened the valve too far, thus giving the engine too much steam, with the result that the engine rapidly overtook the train and came into sharp contact with it. Fairhurst must then have sharply closed the regulator again, and allowed the engine to drop behind the train for the second time. The effect of all this was to give the train a severe jerk and to break the coupling between the second and third vehicles, thereby causing the train to become separated, the vacuum brake to be automatically applied, and the train to come to a stand. When this happened the front and rear portions of the train were about three or four coach lengths apart. Fairhurst, not knowing of the mischief he had done, once more gave his engine steam and again overtook the train, both portions of which were by this time at a standstill, and drove the last 3 vehicles with considerable violence into the front ones. After the accident the bank engine was examined and handled by assistant foreman Patterson (Fairhurst being on the footplate with him), and nothing whatever was found to be wrong with it.

Fairhurst was not injured by the collision, and after suspension resumed duty on the 17th January until the 22nd. On the 23rd he reported himself sick, and on the 26th he died of diabetes, before the enquiry was held. His excuses to the Co. were: (1) the regulator was stiff; (2) that there was a good deal of steam coming from his engine, which prevented his seeing the train. He acknowledged having struck the train once, but said that he knew nothing about striking it the second time. If this be correct, the probability is that it was the second collision and not the first of which he became aware. It is clear that he was exceedingly unskilful in the management of his engine. He was thoroughly experienced, and bore an excellent character as a sober, reliable man. He had, however, been suffering from diabetes for some time past and had been absent from that cause for 3½ months during the summer of 1907. He returned to work in August of that year. It is probable that owing to the fatal complaint from which he was suffering he was daily losing strength, and that latterly he was not in a fit state to take charge of an engine. The regulator handles of the large L. and N.W. engines are placed rather high, and as Fairhurst was short, he would, in his weakened condition, find it difficult to operate the handle with the requisite ease and precision.

This case points to the desirability of a more frequent medical examination of engine drivers, especially after a man has been absent from duty for some months owing to a serious illness.

The Co. are considering the advisability of making some alterations to the regulator handles of their engines by means of an extension, at an angle of 120°, of the existing lever, which will add very considerably to the convenience of drivers and the facility with which they can operate the regulator. It is to be hoped that such an improvement will be carried out as rapidly as possible.

It has always been held by the inspecting officers of the Board of Trade that bank engines assisting passenger trains should be invariably coupled on to the train, and the brake pipe connected. If this had been done in the present instance no such accident as that under consideration would have occurred. The Co. should consider the expediency of adopting this system in future in all cases in which passenger trains have a bank engine in rear.

As the rear vehicle of this train was fitted with the continuous brake, and the brake pipe between it and the train was properly connected, it was hardly necessary to put a bank engine in rear of it merely for the purpose of guarding against the risk of the rear vehicle breaking loose and running backwards down the incline, a thing which could not have happened in this case. On the other hand, if the rear vehicle is not fitted with the continuous brake, or the brake pipe is not connected between it and the rest of the train,* or if the train engine be not sufficiently powerful to haul the train up the incline, a bank engine is, of course, necessary. I therefore think that the Co.'s rule in regard to the attaching of bank engines to the rear of passenger trains on the Atherton-Chequerbent incline might be modified.

*

At **Guisborough Junction, N.E.R.** *On the 1st January. Lieut.-Col. P. G. Von Donop, R.E., reports that:—*

An empty carriage train, consisting of an engine, tender, and 18 vehicles was run into from the rear by an excursion train from Saltburn to Leeds, consisting of an engine, tender, and 8 vehicles. Both trains were fitted with the Westinghouse brake.

Very great damage was done to the empty carriage train. Four passengers have complained of injuries, and the guard considerably and both drivers slightly injured.

Guisborough Junction signal-box, near which this collision occurred,

As is permitted by the Board of Trade Regulations, and when it will not be possible to couple the brake pipe.—Ed. *R.E.

is situated about 500 yards on the down side of Middlesbrough Station, on the Middlesbrough-Saltburn branch of the North-Eastern Railway. Four lines run past this box in the directions which are approximately east and west, the up main line, which is the only one concerned in this accident, being the most southerly of them. The signal-box is situated on the south side of the lines, and is therefore immediately adjacent to the up main line. The collision occurred on the up main line at a point situated about 250 yards to the east of the signal-box.

The next signal-boxes to Guisborough Junction in the Saltbuhn direction are the Whitehouse Crossing and the Cargo Fleet Junction signal-boxes, situated at distances of 1,021 and 1,893 yards respectively from the Guisborough Junction box.

The following signals, which are connected with this accident, are situated as under:—

The Whitehouse Crossing up distant signal—135 yards to the west of the Cargo Fleet signal-box;

The Whitehouse Crossing up rear home signal—385 yards to the east of the Whitehouse Crossing box;

The Whitehouse Crossing up home signal—125 yards to the east of the Whitehouse Crossing box;

The Whitehouse Crossing starting signal, and the Guisborough Junction up distant signal—140 yards west of the Whitehouse Crossing signal-box and 880 yards to the east of the Guisborough Junction box;

The Guisborough Junction up home signal—45 yards to the east of the Guisborough Junction box.

The line from Cargo Fleet Junction signal-box to the point where the collision occurred is almost straight, except where it runs through Cargo Fleet Station, where there is a slight curve to carry the line round the island platform. The gradient between Whitehouse Crossing and Guisborough Junction signal-box is practically level. The signals are all placed so that the driver of an up train approaching Middlesbrough gets an excellent view of them. The night of the accident is stated by all the witnesses to have been clear and dry.

Driver Wheatley, of the excursion train, states that the Whitehouse Crossing distant signal showed more green than red light. In spite, however, of having noticed that this distant signal was doubtful, he ran past the Whitehouse Crossing rear home and home signals without seeing either of them. He ascribes his not seeing the former to the fact that he was at the time attending to his injector, and his not seeing the latter to the steam and smoke from his engine. When he was, however, about 100 yards from the Whitehouse Crossing starting signal, and whilst his train was going at a speed which he estimates at 30 miles an hour, he sighted the starting signal, and saw that it was at danger. He at once turned off steam and applied his brakes, but he was unable to bring his train to a stand before running into the tail end of the empty carriage train, at a speed which he estimates as 6 or 7 miles an hour, but which from the damage done is evidently a very low estimate. The evidence is in direct contradiction of Wheatley's statement that the signal was a doubtful one.

It is difficult to credit driver Wheatley's statement that when he turned off steam and applied his brakes he was at a point 100 yards before reaching the Whitehouse Crossing starting signal. If this were the case, he would at that time have been at a distance of 730 yards from the rear of the empty carriage train and would have had no difficulty in stopping his train before reaching the empty carriage train. Guard Rispen, of the excursion train, states that in his opinion the brakes were not applied to the train until a very short time before the collision.

Wheatley has been for 32 years in the service, the last 10 of which as a driver. He has an exceedingly good character and record. He had come on duty at Leeds at 11.45 a.m., had started from there at 12.45 p.m., and had arrived at Saltburn at 3.49 p.m. He had then had a clear four hours' rest, during which interval he was able to leave his engine, and he had started back from Saltburn on his return journey at 10.30 p.m. Witnesses who saw him—both before and after the accident—concur in saying that he showed no signs of suffering from the effects of drink.

*

At **Coxhoe Junction, N.E.R.** *On the 18th January. Lt.-Col. P.G. von Donop, R.E., reports that:*—

The 3,25 p.m. passenger train (engine and 4 carriages) from Ferryhill was partly derailed. The left-hand side of the third carriage was dragged into contact with a small platelayers' cabin, which was demolished, and 22 passengers complained of injuries.

Coxhoe Junction is about one mile north of Ferryhill, N.E.R. There is a double junction with a facing connection on the Hartlepool down line. The left-hand lines branch off in a north-westerly direction to Bishop Auckland, whilst the right-hand pair, which curve slightly to the right, run on to Hartlepool. The train was running through the junction on the Hartlepool down line, and its derailment occurred at the diamond crossing where that line crosses the Bishop Auckland up line.

The facing points on the down line are properly locked and detected, and after the accident were uninjured in any way. The lines to Hartlepool are on a gentle right-hand curve of 42½ chains radius, whilst those to Bishop Auckland are on a left-hand curve of 17 chains radius. The permanent way is of the N.E.R. standard type; 90lbs. rails and ballast of coke.

The evidence throws no light on the cause of the derailment. The speed of the train through the junction was not more than about 25 miles an hour. The curve of the line was 42½ ch. radius.

The driver and fireman of the train knew nothing of the accident until they noticed the sudden application of the continuous brake, caused, doubtless, by the disconnection between the third and fourth vehicles, and they then at once took all necessary steps to stop the train. The guard states that he noticed when his van was running through the facing points, and that it ran through them quite smoothly; he thinks, however, that it was when the crossing was reached that he was thrown down, after which all he can remember is that his van was rolling and rocking about until it came to rest.

After the accident the engine and 3 leading vehicles, coupled together, were on the Hartlepool down line, the rear end of the last vehicle being just 90 yards beyond the fork; the wheels of the engine and of the two leading vehicles showed no signs of having been derailed. The third vehicle had all its wheels derailed on the left-hand side. The rear or fourth vehicle, which was entirely separated from the rest of the vehicles, was on the Bishop Auckland up line about 60 yards beyond the fork; the four wheels of its leading bogie were all derailed to the left of that line, whilst those of the rear bogie were all on the rails.

The condition of the two rear vehicles of the train was found to be excellent.

The marks on the line point conclusively to the derailment having originated with the right-hand wheels of the leading bogie of the rear vehicle of the train. After being thus derailed to the left of its proper line this vehicle would, at the obtuse-angled crossing of the diamond, be compelled to follow the rails of the Bishop Auckland up line; in so doing it would tend to pull the rear of the next or third vehicle of the train off its line in that direction, and that condition of affairs would continue until the coupling between them broke, when the third vehicle would be pulled by the engine back again towards its own line. The above appears undoubtedly to have been the course of events which occurred in connection with this derailment. Little or no injury would have been caused to any of the passengers had it not been that the third vehicle, whilst derailed, fouled the platelayers' hut situated in the fork between the two lines, and the side of the carriage was ripped open thereby.

The crossing on the right-hand rail of the Hartlepool down line at which this derailment originated was a V-crossing of an angle of 1 in 8, and the train was running through the V in the trailing direction. The right-hand rail of the Hartlepool down line and the left-hand rail of the Bishop Auckland up line were, as is customary in such crossings, bent back to form wing rails opposite the V, and a check rail was also provided on the inside of the left-hand rail of the Hartlepool down line, opposite the V-crossing. The V-crossing and the wing and running rails were secured to five crossing chairs of the usual description, and it was found after the accident that four of these were broken, viz., the two in which the point of the V and wing rails rested, and the two ahead of these to which only the running rails were secured. The crossing was so much damaged that the gauge of the line at it at the time of the derailment could not be definitely ascertained, but immediately after the accident it was tried at a point situated about 6ft. in rear of the crossing, and was found to be ⅜in. wide to gauge.

The top inside edge of the wing rail lying to the right of the V was found after the accident to be very considerably worn away, the portion which was specially worn being that situated about three feet from the knuckle of the crossing; this is the spot where a wheel running through the crossing should first obtain its footing on the wing rail, and it is evident that wheels have been rubbing against the inside of that rail before getting a proper footing on it. The wing rail was, undoubtedly, worn away to a dangerous extent, and it should certainly have been noticed and renewed long before this accident occurred.

The rails of this crossing were laid entirely on ordinary sleepers of the usual dimensions; it is generally the custom at such crossings to employ special timbers of larger dimensions, known as crossing timbers, each of which carries the four rails of the two lines of way on each side of the crossing, and holds them firmly together in their proper relative positions; in this case, however, no such timbers were employed, and the number of sleepers in the neighbourhood of the crossing carrying the two rails of the Hartlepool line and tying them to gauge was unusually small. It is also customary on most lines for a strong bolt to be provided at the knuckle of the crossing, holding the two running rails firmly together at that point, but in this case no such bolt was provided. In consequence of the above-mentioned defects the rails at this crossing were not very securely tied to gauge, and the crossing must be considered as having been one of distinctly weak construction.

From the condition in which the wing rail was found it is evident that, as stated above, for some time past wheels running through the crossing have been rubbing against the inside edge of this rail, and wearing it away before getting their proper footing on the surface of it. In so doing, the wheels would tend to force the wing rail outwards, and, as the wearing away of the rail continued, the lateral pressure would increase. In consequence of the deficiency of sleepers, the two rails were not very securely tied to gauge on either side of the crossing; and this lateral pressure would consequently fall largely on the crossing chairs, and the probability is that eventually one of these chairs broke under the strain. The wing rails being then no longer held together, the gap between them at the point of the V became large enough to allow of the wheel falling into it, and the derailment of the train ensued accordingly. The above appears to be the most probable cause of this derailment, which must therefore be attributed to the breaking of one of the crossing chairs, that breakage being in turn due to the worn condition of the wing rail and to the weak construction of the crossing.

EDITOR'S NOTICE.—All manuscripts and communications should be distinctly written, or preferably type-written, on one side of the paper only, and addressed to the Editor, **3, Ludgate Circus Buildings, London, E.C.** The Editor cannot undertake to return rejected manuscripts or drawings unless accompanied by a stamped directed envelope.

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Railway Engineer

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Contents.

Lord Wolverton has been elected treasurer of the Railway Benevolent Institution in succession to **Lord Hillingdon**, who has retired.

Sir Wm. Hart-Dyke, Bart., deputy chairman of the L. Chatham and Dover R., has been elected chairman in place of **Sir E. Leigh Pemberton, K.C.B.**, who has resigned the position (but not his seat on the Board) on account of failing health. **The Rt. Hon. A. Akers-Douglas, M.P.**, director, has been elected deputy chairman.

Major H. C. Cusack, deputy chairman of the Midland Great Western R., has been elected deputy chairman of the Bank of Ireland.

Mr. J. Puplett, treasurer of the L., Brighton and S.C.R., has retired after a service on the railway of more than 48 years. He was appointed treasurer in 1893.

Mr. A. E. Pitcher, of the Indian Government Telegraph Department, has been appointed telegraph superintendent of the South Indian R.

Mr. F. R. Slack, has been appointed district locomotive superintendent of the Midland R. at Worcester.

Mr. Chas. J. Nicholson, passenger superintendent, Lancashire and Yorkshire R., retired on the 31st ultimo, after 20 years' service. He was chairman of the Railway Clearing House Superintendents' Conferences in 1899.

Mr. Arthur A. Haynes has been appointed superintendent of the line of the Furness R., in succession to **Mr. Frederic J. Ramsden**, who has retired.

Mr. K. R. Speir, general secretary of the Egyptian State Railways, has been appointed assistant to the general superintendent of the Midland R.

Mr. John Cowper, goods agent at Greenock, Caledonian R., has been appointed goods superintendent at Buchanan Street, Glasgow, and **Mr. W. H. Martin** to the similar post at Port Dundas.

Mr. F. Clements has been appointed station master at St. Pancras, Midland R., in succession to **Mr. W. P. Snow.**

Mr. Wm. Hamilton has been appointed superintendent at Princes St. Station, Caledonian R., Edinburgh.

We regret to record that **Mr. J. Hurman**, superintendent, Cardiff R., died on the 8th ultimo, aged 67.

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L. and North Western and Midland Agreement.

THE most important event in the railway world last month was the announcement that the L. and North Western and the Midland Railway Companies had concluded a working agreement which is to last until 1999. Lord Stalbridge outlined the agreement to the shareholders as follows:—

As you know, the geographical positions of the two Companies are such as to place them in competition for traffic between many important places. We have long desired to arrive at a means of so combining the interests of the two companies as to enable the traffic in which both are interested to be carried on with thorough efficiency united with the greatest economy, consistent with that efficiency, in the common interest of both companies. Many arrangements have been made with our Midland friends with this object, but they have hitherto, though important, been of a minor character. Now, however, I am glad to say that we have been able to make an agreement which will, we hope and believe, have very important results. Its principles are, first, the elimination of all inducements to excessive competition, which, while expensive, produce no additional traffic, and, second, co-operation in the working of all competitive traffic in the manner most convenient to the public and most economical to both companies. These being the principles, the mode of application is the division of receipts from competitive traffic in certain proportions based upon the actual carryings of the two companies over a given period in the past. It cannot be otherwise than a gradual business to ascertain where, and in what ways, the working of the traffic can be improved and economised. This work, however, is in progress, and the inducement to the abstention from expensive competition is in full force, because the settlement of accounts, when necessary figures have been ascertained, takes effect from the 1st July last. You may be sure that we shall lose no opportunity of extending the arrangement, to the advantage alike of the public and of the shareholders, applying, if necessary, to Parliament for further powers.

*

Locomotive Coal and Dividends.

THE past half-year has been a bad one for railway shareholders, as all the dividends are less than for the corresponding period of last year. The figures given below show the main cause.

Railway.	Loco.-Coal. + £	Net Revenue. − £
L. and North Western	152,222 ...	290,378
Great Western	44,362 ...	54,468
Midland	76,840 ...	196,022
North Eastern	16,040 ...	240,510
Great Central	38,643 ...	73,405
Great Northern	38,000 ...	51,000
Lancs. and Yorks	22,079 ...	91,112
Great Eastern	43,951 ...	45,673
L. and South Western	33,772 ...	42,372
L. Brighton and S.C.	12,128 ...	15,264
South Eastern and C.	21,477 ...	78,570

*

International Rubber Exhibition.

THE first complete Rubber (and Allied Trades) Exhibition ever held will open at Olympia on the 14th and continue until the 26th inst. Some idea of the magnitude of the rubber trade may be gathered from the fact that raw rubber valued at £10,834,759 was imported into this country last year. As we understand that there will be exhibits from all parts of the world, and that rubber in all its stages, from the seedling trees to articles made of the finest and poorest grades will be shown, the Exhibition should be a highly interesting and very instructive one. Almost countless articles, wholly or partly made of rubber, are used on railways.

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Notice of Removal.

THE United States Metallic Packing Co., Ltd., whose works and headquarters are at Bradford, Yorks, give notice that they have removed their London Offices from 17, Victoria Street, Westminster, to 10, Fenchurch Street, E.C.

Automatic Couplings.

THE third and fourth Reports of the Railway Employment Safety Appliances Committee were issued in one White Paper (Cd. 4213) on the 14th ultimo.

The principal, most interesting, and far-reaching feature of these Reports is a memorandum prepared by Colonel Yorke—the chairman of the committee—under date August 8th, 1907, addressed to the Assistant Secretary of the Railway Department on the subject of Automatic Couplings. Unfortunately we have not space in this issue to reproduce this memorandum in full. It goes deeply into the reasons given by advocates of automatic couplings for their use in this country; the cause and the need for their introduction in America; a comparison as to the number of casualties in coupling and uncoupling on British and American railways; the vastness of the question in this country as to disturbance of traffic during the equipment of stock with automatic couplings; the cost; the length of time to do the work; the private owner. We will, however, briefly note Colonel Yorke's main points which, it must be admitted, at once effectively dispose of the question of automatic couplings for goods stock in the same way as the same committee's report in the summer of 1907 disposed of that of either-side brakes.

The memorandum begins by observing that the necessity for making automatic couplings compulsory rests upon the assumption that the safety of the men would be largely increased by such appliances, but that this necessity is not so great as is generally imagined. The figures as to casualties in coupling and uncoupling vehicles for 1905 were 12 killed and 523 injured, and 9 killed and 572 injured during 1906. These figures compare with 18 killed and 481 injured during 1898—the year of the Royal Commission on Accidents to Railway Servants—and show a gratifying decrease in the number of fatal cases, and whilst the number of non-fatal cases have increased it must be remembered that more accurate returns are now rendered and that there has been a large increase in the number of men employed in the engines and vehicles used and in traffic carried. The first point would then appear to be that there is not the necessity for automatic couplings in Great Britain that is generally imagined.

Point No. 2 is that automatic couplings, if introduced, will not remove all danger to men engaged in shunting. The uncoupling will still have to be done by hand by means of a lever or handle at the side, and therefore the men will continue to be amongst moving vehicles. They will also still have to go between the wagons to adjust the couplings, and, in fact,oftener than now, as vehicles will frequently automatically couple unnecessarily. Then there is the question of brake and steam-heating pipes, and as there is a gradual tendency to equip goods vehicles with continuous brake pipes this difficulty does not apply to passenger stock alone.

The next question dealt with by Colonel Yorke is the transition stage—a period that will vary in length according to whether automatic couplings are to be attached to all vehicles or only to new ones. If the latter, then the transition period will be a mighty long one, because, as the memorandum says, a wagon may be renewed and repaired from time to time that after a certain number of years nothing remains of the original wagon but the registration plate. But be the transition stage long or short it will bring a sheaf of troubles. There will be the delays due to joining up a wagon with a link coupling to one with an automatic coupling, and the danger to the men will be the greater during that time owing to the more frequent necessity for them to go between the wagons to adjust dissimilar couplings.

Colonel Yorke, at this point in the memorandum, returns to the question as to the need for automatic couplings, and shows that in America something had to be done. The link and pin coupler was what was used there and it was necessary for a man to go between the cars whilst they were being brought together and to hold the link in one hand between the central buffers (into the jaws of which the link had to be guided) until these buffers were nearly in contact with each other, and then to snatch his hand away so as to avoid its being crushed, while with the other hand he dropped the pin into its place. Automatic couplings are now in universal use in America, yet during the year ending June 30th, 1905, there were 243 men killed and 3,110 injured, and 311 killed and 3,503 injured during the year ending June, 1906. These compare with 12 killed and 523 injured during 1905 in Great Britain, and 9 killed and 572 injured during 1906.

Now we come to the question of cost. From the Board of Trade returns and from enquiries made by the committee it would appear that there are 750,000 wagons belonging to railway companies and 650,000 belonging to private owners—a total of 1,400,000. The number of passenger stock is 70,500. Here Colonel Yorke interjects figures to show that more accidents occur with passenger stock than with goods stock, as the former have screw couplings which compel a man to go between the carriages in order to tighten up or release the screw. With the 70,500 passenger vehicles there were in 1905 4 servants killed and 160 injured, and in 1906 4 killed and 241 injured. With twenty times as many goods wagons there were for the same years 8 killed and 349 injured, and 5 killed and 330 injured. The memorandum then explains that it is not the simple matter generally imagined to exchange an automatic coupling for an ordinary one, and it shows how the framework has to be reconstructed to withstand the shocks on a central buffer instead of along the side members. A good deal of time and money will therefore have to be spent upon every wagon in order to render it fit for automatic couplings. Couplings vary in price. Some being tried in India and the Colonies cost £15 per wagon (£7 10s. per coupling) for standard gauge, and £12 for metre gauge, but this does not cover any strengthening of the wagon. Assume though, for the sake of argument, that £10 per wagon would cover everything, this would mean an expenditure of £14,000,000. Were this spread over a number of years this would not be so serious, but owing to the greater danger to the men it is desirable that the transition stage should be as brief as possible. Then look, too, at the cost to the trade of the country owing to the dislocation due to the wagons being withdrawn from traffic. If the work is to be done in ten years and each wagon takes two days to alter it would mean that 940 wagons per day for 10 years would have to be taken out of traffic. No wonder, then, that Colonel Yorke remarks "It would seem, then, that a dilemma is reached from which there is no escape."

Not the least of the problems is that next submitted:—How are the private owners to be compelled to undertake the expenditure necessary? The only way the Board of Trade can reach them at present is to prohibit railway companies after a certain date receiving wagons without automatic couplings. But supposing all the private owners were to agree amongst themselves not to adopt an automatic coupler, what then? The remedy is for the railways to buy up the stock, but this would entail a further large capital outlay. "Whatever the remedy may be, I have no doubt that if automatic couplings are ever to be introduced into this country, legislation of a drastic character will be necessary."

The main difficulty is, then, not a mechanical one, but a financial one, and so Colonel Yorke concludes his memorandum, "I feel sure that it is no use attempting to initiate experiments with automatic couplings till some practical scheme has been formulated for meeting the expense, not only of the ultimate change from one type of coupling to another, but also of the trials and experiments which will have to be made. . . . It would hardly be fair to encourage them [inventors] to come forward unless there was some reasonable prospect of the introduction of automatic couplers being carried through. The experiments themselves will cost a large sum of money, and will have to be extended over many years. Models will be of little use for the purpose, and even for the preliminary examination of any coupler it will be necessary for three or four wagons at least to be fitted with them. Such an examination will have regard to the mechanical features of the appliance, its weight, simplicity, certainty of action and ease of release. After weeding

out those designs which are clearly unsuitable in any of the above respects there will remain others which will require a practical test in ordinary working. For this purpose it will be necessary for whole trains of not less than, say, 50 wagons each, to be equipped with the different couplings to be tried, and these trains will have to be put into traffic under the most unfavourable conditions in various parts of the country for at least 12 months in order that the reliability, strength, durability, safety, etc., etc., of the couplers may be investigated. . . . . . . I submit this memorandum for the consideration of the Board of Trade. From the remarks contained therein it will be gathered that the issues involved in, and the difficulties connected with, the proposal to render the introduction of automatic couplers compulsory in this country are almost insuperable. I do not think that their magnitude has hitherto been sufficiently appreciated. The question is of national importance, and it is, I submit, for the Government of the country to decide (1) Whether, having regard to the small number of accidents in this country due to the present method of coupling and uncoupling goods wagons, there is any such necessity for a change from the existing type of coupler as to justify the large capital outlay and the dislocation of traffic which would be inevitable. (2) How, if the change is decided upon, the enormous expenditure connected therewith is to be met. (3) How the owners of private wagons are to be dealt with. (4) How the dislocation of traffic and risk of accident to men and trains during the experimental and transition stages are to be faced. Until these questions have been considered and answered it will be inexpedient and useless to initiate a series of long and costly experiments for the purpose of selecting the automatic coupling best suited to English rolling stock."

This memorandum was referred to the Railway Employment Safety Appliances Committee—the other two members of which are Mr. Robert Turnbull, of the L. and North-Western R., and Mr. Richard Bell, M.P.—and they report that they entirely agree with the remarks contained therein, but they suggested that some effort be made whereby the three-link coupling could be put on and taken off the drawbar hook by some other means than by the shunting pole. As a result of this the committee have received and examined twelve models designed to accomplish this object. It was generally found that these appliances fell under two headings, viz., those which retain and operate upon the existing three links, and those where one link or two links are substituted for the present wagon coupling, the drawbar hook remaining unaltered. The committee are inclined to think, at present, that appliances of the former description are preferable to those of the latter.

Notes on Locomotives.

Besides the two types of "Pacific," or 4-6-2 locomotives described in our last two issues, there is another which has been introduced on the Western Railway of France—now part of the State system. This engine contains features distinct from the usual French designs for four-cylindered compounds.

As regards the arrangement of wheels and cylinders the custom prevailing in the Glehn type is followed, namely the dividing of the cylinder power over two distinct axles. In the engine now under review, however, the H.P. cylinders are placed between the frames and drive the leading coupled axle, the outside L.P. cylinders driving the middle axle. In order to avoid the otherwise long wheelbase resulting from such an arrangement, the H.P. cylinders are placed well ahead of the bogie centre, hence reasonably long connecting rods have been possible. Each cylinder is controlled by a separate piston valve, each actuated by a separate set of valve gear; this latter is of the Walschaerts pattern, but is modified inasmuch as the motion for the inside valves is obtained without eccentrics on the axle, by means of double return cranks and a system of levers and rocking shafts. As this motion is out of the ordinary we hope to illustrate it in our next issue.

Owing to the use of the wide firebox of the Belpaire type all the coupled wheels are placed under the barrel of the boiler, consequently this latter is of great length—19-8½ between tube plates, although the firebox is inclined to avoid excessive weight on the trailing axles. The trailing wheels are mounted in a radial armed bogie, with the springs connected to those of the trailing coupled wheels by compensating beams; all the other coupled axle springs are similarly connected.

The principal dimensions of this engine are given in the following table, in which we have included the other European types of "Pacific" engines, also the same type for the Pennsylvania Railway, the latter serving to show how far behind, as regards mere dimensions, is the largest European design.

Railway.	*Western (France).*	*Paris-Orleans.*	*Baden State.*	*Great Western.*	*Pennsylvania.*
Cylinders, H.P. ...	15¾ × 25¼	15⅜ × 25⅝	16¼ × 24	15 × 26 (4)	24 × 26
,, L.P. ...	22 × 25½	25⅛ × 25⅝	25⅝ × 26⅜	—	—
Ratio	1: 2·56	1: 2·77	1: 2·33	—	—
Wheels, coupled ...	6ft. 4in.	5ft. 10in.	5ft. 10⅞in.	6ft. 8½in.	6ft. 8in.
,, bogie ...	3ft. 2⅛in.	3ft. 0in.	4ft. 0in.	3ft. 2in.	3ft. 0in.
,, trailing ...	4ft. 7⅛in.	3ft. 7⅜in.	3ft. 3⅝in.	3ft. 8in.	4ft. 6in.
Wheelbox, coupled	13ft. 3in.	12ft. 9in.	12in. 11in.	14ft. 0in.	13ft. 10in.
,, total ...	34ft. 8 3/10in.	34ft. 5in.	37ft. 0in.	34in. 8in.	35ft. 2½in.
Boiler					
Barrel diam. largest	6ft. 5in.	5in. 6in.	5ft. 7in.	6ft. 0in.	6ft. 11¼in.
,, ,, length	19ft. 8½in.	19in. 4¼in.	17ft. 0ins.	23ft. 0in.	21ft. 0in.
Firebox, length ...	—	9ft. 3⅞in.	—	8ft. 0in.	10ft. 1⅝in.
,, width ...	—	6ft. 10¾in.	7ft. 11in.	5ft. 9in.	7ft. 7⅞ft.
Grate area	43sq.ft.	45·93sq.ft.	48sq.ft.	41·7sq.ft.	sq.ft.
Heating surfaces, tubes	2892 ,,	2603 ,,	2088 ,,	2673 ,,	4243 ,,
,, superheater	—	—	538 ,,	545 ,,	—
,, firebox ...	150 ,,	165 ,,	158 ,,	182 ,,	205 ,,
,, total ...	3042 ,,	2768 ,,	2784 ,,	3430 ,,	4448 ,,
Pressure	227 lbs.	227 lbs.	227 lbs.	225 lbs.	205 lbs.
Weight, full, adhesion	53·5 tons	52·05 tons	50·4 tons	60 tons	74·4 tons
,, ,, total ...	90·6 ,,	89·5 ,,	89·8 ,,	96 ,,	182·6 ,,

Although to a certain extent the "Atlantic," or 4-4-2 type of engine has not made the headway in this country that was expected of it at the inception of the type, still on certain of the Continental lines this type continues to find favour, more especially, as is natural, on lines having a fairly easy contour; among the latest examples of this type are the engines of the Hanover State and Danish State Railways.

The former is a fine design, embodying in it the best features of the previous engines of the same type built for this railway. The boiler has a wide firebox of the round-topped pattern standard on most German lines; the barrel is of the wagon-top type, with a taper ring next to the firebox; the smokebox tube plate is set well back to relieve the bogie of the weight of the boiler. Owing to the wide firebox the trailing axle is placed behind it, making the total wheelbase rather long for an "Atlantic" engine, namely 35-ft. 3.2-ins.

The four compound cylinders are placed side by side under the smokebox, the high pressures being inside the frames all drive the same axle. Walschaerts valve gear, actuated from return crank, drives the low pressure valve direct, the motion being communicated to the high pressure valve by rocking shafts. A starting valve is provided to admit live steam to the L.P. cylinders at starting. The following are the main dimensions :—

- Cylinders, H.P., 14.9-in. by 23.6-in.; L.P., 22.8-in by 23.6-in.
- Wheels, coupled, 6-ft. 5.9-in.; Bogie, 3-ft. 3.3-in.; Trailing, 4-ft. 1.2-in.
- Wheelbase, coupled, 7-ft. 6.5-in.; total, 35-ft. 3.2-in.
- Steam Pressure, 200-lbs.
- Boiler, barrel diameter front, 5-ft. 2.2-in.; length between tube plates, 17-ft. 7-in.
- Firebox, length, 6-ft. 4.7-in.; width, 6-ft. 8.7-in.
- Grate area, 43 sq. ft.

Heating surfaces, tubes, 2,628 sq. ft.; firebox, 208 sq. ft.; total, 2836 sq. ft.
Weight full, adhesion, 33.08 tons; total 74.73 tons.

The Danish engines differ in many respects from those described above, having several features more common to American practice than European, and for this reason they are of more than ordinary interest. Like most Continental engines now being built, other than those fitted with super-heaters, these engines are four-cylindered compounds. The system used is that brought out by the Baldwin Loco. Works, which is balanced and divided, but all the cylinders are placed abreast; each pair of high and low pressure cylinders are controlled by a single double-ported piston valve, requiring, of course, but one set of motion. The high pressure cylinders are between the frames and drive the leading coupled wheels, the outside cylinders being connected to the rear drivers. The leading axle has the eccentrics placed on it between the cranks and the axlebox, so as to get as direct a valve gear as possible.

Another American feature is the frames, which are of the bar form, which lends itself very well to the Vauclain form of cylinders, in which the steam chest is placed above and between each pair of cylinders. The rear end is of slabs, as this form is most convenient when a trailing axle is used. The springs of the coupled and the rear axle are all connected in one séries by compensating beams.

The boiler is of the wide firebox type, the width inside the box being 6-ft. 4.4-in. The barrel is in two rings, of which the rear one is coned with a maximum diameter of 5-ft. 11.6-in.

Cylinders, H.P., 13.38-in. by 23.62-in.; L.P., 22.44-in. by 23.62-in.
Wheels, coupled, 6-ft. 6.1-in.; bogie and trailing, 3-ft. 5.49-in.
Wheelbase, coupled, 6-ft. 10.6-in.; total, 29-ft. 4.36-in.
Steam pressure, 213-lbs.
Heating surface, tubes, 2,174 sq. ft.; firebox, 130 sq. ft.; total, 2,304 sq. ft.
Grate area, 42 sq. ft.
Weight full, adhesion, 32.45 tons; total, 66.83 tons.

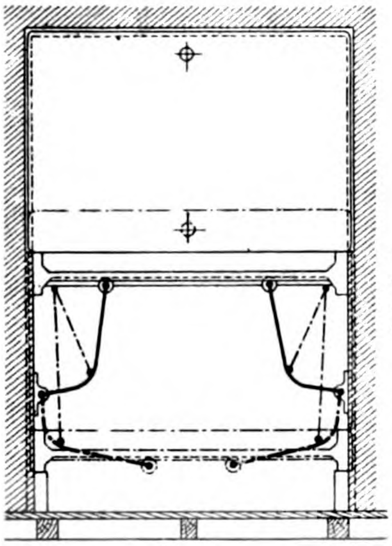

Fig. 2.

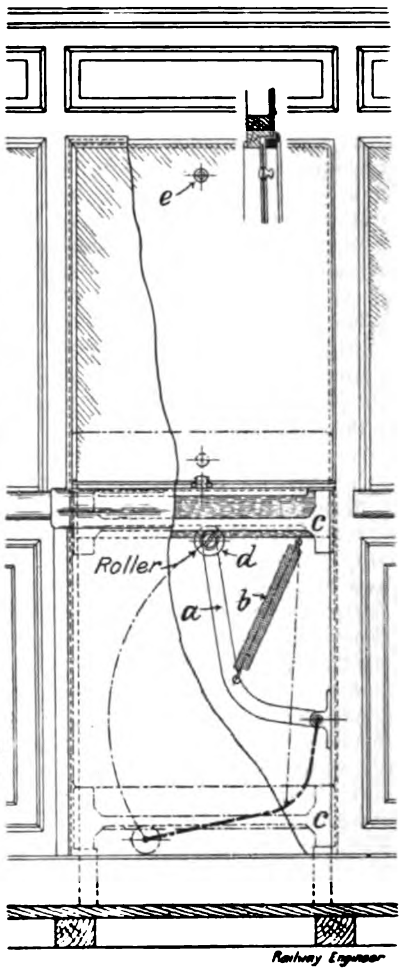

Fig. 1.

Chevalier's Balanced Drop-Light and Draught-Excluder.

Among the things which can be found if one searches at the Franco-British Exhibition is Chevalier's Drop-Light and Draught-Excluder for railway carriages and motor cars. We found this appliance behind a screen at the end of the *C. de f du Nord's* exhibit.

This system of Drop-light is extensively used on the Continent, particularly on the State railways of France, and of Belgium and the *Ouest* of France. The saloon of the French President is fitted with them.

In this system no frame is used round the drop-light, plate-glass 7 to 8 *m/m* ('27 to '31in. thick with the edges rounded and polished being used. It is said that the maintenance of the wood frames, as used in this country, is costly.

It will be noticed, figs. 1 and 2, that the balancing arrangement is very simple and consists only of one (or two according to the sike of the window) bent lever *a* hinged to the frame and supported by a coiled spring *b*, one end of which is attached to the door or body framing. The glass rests on a cross bar *c* which rests on the roller *d* attached to the free end of the bent lever *a*. It follows that as the glass descends and the effective length of the lever *a* increases, the tension of the spring also increases, and thus the glass is balanced at any height of its travel. The glass is easily raised or lowered by means of the knob *e* which is fixed to it.

When the glass is at the top it is not thrown over the garnish rail, but a hinged metal cover is passed under it and

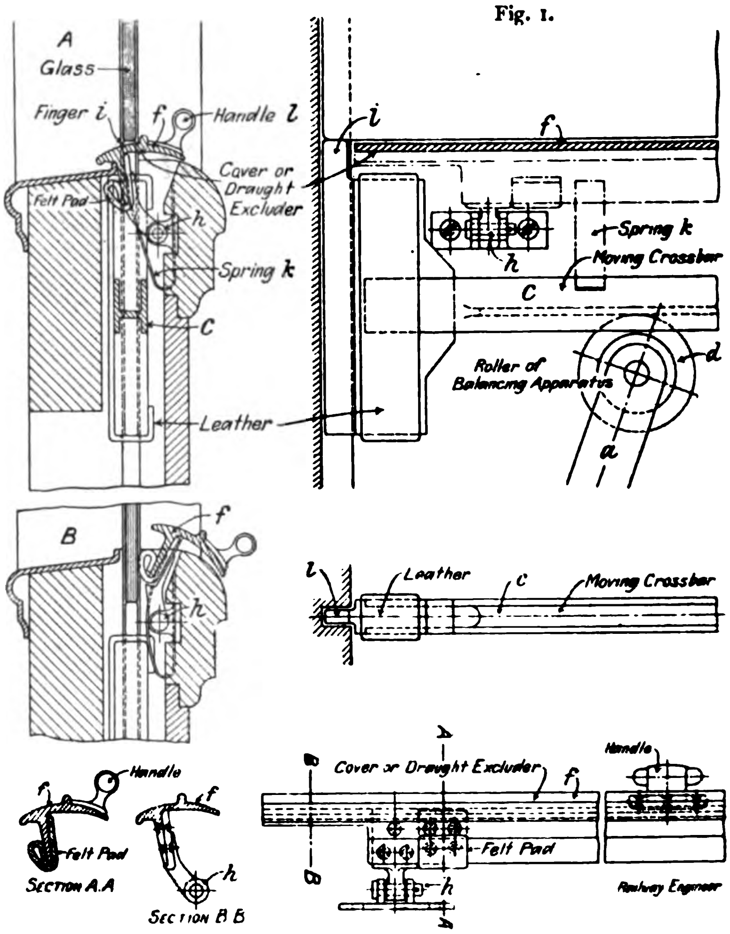

Fig. 3.

the glass pulled down on to it. As the glass is always tight in its run, rattling is easily prevented. The metal cover or draught excluder is illustrated in detail by fig. 3. It is hinged at *h*, the glass rests on elastic fingers or supports *i* at the sides, and which are attached to the cross bar *c*. The cover *f* is always pressed outwards by the springs, and the hinges are provided with felt pads which press against the glass except when it is fully raised. To close the window the glass is raised and the cover *f* pushed under it, to open the window the cover *f* is pulled from under the glass without effort by the handle *l* and the glass at once falls on to the balancer and may be pulled down to the desired position.

The maker of this fitting is Mons. H. Chevalier, 61, quai de Grenelle, Paris.

Books, Papers, and Pamphlets.

The Design of Typical Steel Railway Bridges. By W. Chase Thomson, M.Can.Soc.C.E., Assistant Engineer, Dominion Bridge Co., Ltd., Montreal, Canada. London: Archibald Constable & Co., Ltd., 1908.

We cannot understand why books of this class so frequently claim to be of an "Elementary" character. The adjective may indicate modesty on the part of the author, but is often, as in the present instance, an inaccurate definition, since the information that the book contains would enable anyone to completely design several complete types of bridges, and, in fact, the Author assumes fairly complete elementary knowledge before he commences to write his introduction.

The book is a sequel to the Author's work on "Bridge and Structural Design," and consists of full descriptions and details in as many chapters of half a dozen types of railway bridges, including a plate girder, a deck Warren girder, a through Pratt truss, a through Pratt truss with curved top chord, a swing bridge, an the usual type of American railway viaduct.

This method of working out examples after the theory of stresses has been discussed, is followed in several American books of this class, notably by Merriman and Jacoby, Johnson, Bryan and Turneame, etc., etc., but in the book before us, the two sides of the question, the theory and the example, are cleverly blended into each other as progress is made, with satisfactory results.

In each case this is completed by the writing out in detail the weights of the structures described. In our opinion this is given at too great length, since given the working drawings of any structure and one full example there is no difficulty in ascertaining the weight of any girder work. In any case it does not seem necessary to work it out fully in the six different cases.

An introductory chapter deals with the vexed question of unit stresses on bridges, and the queston suggests itself why some international Commission on standards has not given an authoritative pronouncement on how to provide for impact and vibrations, and what proper factor of safety to assume in constructional work.

Turneam's experiments on deflections are referred to, which are said to show a maximum increase of 45 per cent. from impact and vibration under rapidly moving train loads. The writer has taken the deflections of many bridges on first-class railways in Great Britain, but has certainly not found this percentage of increase from moving loads, a point which may indicate that a better and stiffer permanent way is to be found on British bridges than the American bridges possess, or on the other hand, that the locomotives are better balanced.

We appreciate the honesty of the author in referring his readers to other technical books for a fuller discussion on column and other stresses, a reference which in no way detracts from the book, and is very convenient to a busy man who has not overmuch time to find references for himself. The formulæ are, however, given at sufficient length, quite ample enough for the purpose.

The provision that one-eighth of the area of the web plate is to be added to the flange area for flange stress is not usually accepted in English practice, but the next point, referring to Mr. Schaub's paper, is interesting where it is shown that if the load be suspended below the bottom flange of a girder, no intermediate stiffeners of any kind are required. Of a certainty, the function of the web is by no means yet fully understood.

An example of the moment and shear diagram for moving loads is given, and how to find the position of the loads which gives the maximum moment on the span, briefly, "if the centre of gravity of the total load on the span coincides with a wheel concentration, the maximum moment will occur under this wheel, when placed at the centre of the span. If the centre of gravity of the load falls between two wheels, the maximum moment will be under one of these (usually the wheel nearest the centre of gravity), when the wheel considered and the centre of gravity are equidistant from the centre line of the span."

The rivet spacing in flanges is amply and clearly described, and the splicing of the plates, but we cannot but notice the light stiffening of the web shown in the detail drawing. In this case very light single angles are used on each side of the web, where in plate girders of similar size on this side of the water we should have nothing less than a pair of strong angles with a substantial gusset plate at right angles to the web, even if the gusset itself was not stiffened down its outside edge.

The deck Warren girder, and the two examples of the through Pratt truss, are of the usual American type, with an extreme depth and high portal at each end. An open girder, of whatever type it might be, where the depth is only one-fifth of the span, would seem very much out of place in England, and although there would be a gain in rigidity, and an advantage in securing high overhead bracing, yet the structure appears to be of far too spidery a character. Again, a bridge with height of 30-ft., but with a clear width of only 16-ft., which does not seem sufficiently stable, however it may be braced overhead and below.

The very different and extremely complicated cases of the loading of the swing bridge are thoroughly dealt with, but here again we have a depth of 28-ft. to a clear width of 16-ft., which does not seem satisfactory, especially in a moveable bridge where all kinds of wind loading may be expected. Here again the drawing and stress diagram are ample and excellent, and the finding of the different reactions is clearly described and illustrated. The working out of the details of the gearing is fully dealt with, and the proportioning of the rollers, centre pivot, and end lifting arrangements. We wish, however, that we could find some treatment in language easy to understand, of the earlier small swing bridges where both ends of the swing span are supported by means of tie rods, sloping down towards the ends, otherwise the toe and heel, from the top of one or more supporting pillars resting on a ring of live rollers. It is easy enough to get information referring to the large swing or draw bridges of to-day, but the information is very scant with regard to the older type of swing bridge such as we have mentioned.

There is nothing striking in the next two chapters dealing with "Railway Viaducts" and "Additional Types of Steel Railway Bridges," and this brings us to the concluding chapter on "The Latticing of Compression Members."

This is an explanation or modification of Morris' method, published in the *Engineering News* in November and December, 1907, of course with a view to the Quebec failure. The proof of the correctness of such formula is of course only possible where tests are made of full-size members, but we note that our author has applied the formulæ satisfactorily to the compression members of the several examples given earlier in the book, and proceeds to argue from this that

the result would be equally satisfactory if applied to other columns braced with lattices.

We should have liked to have seen the formula applied to the Quebec member that failed, with a few hints showing how an improvement could have been made.

The explanatory matter is well written, the diagrams and drawings are clear and excellent, and the book should be of great use to the engineer of bridges.

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Locomotives a Vapeur. By J. NADAL, assistant chief Locomotive Engineer French State Railways. Illustrated. Paris: O. Doin.

This book, the text of which is in French, is almost entirely devoted to modern steam locomotives, as during the last 20 years locomotives have made such progress that the oldest types have now only an historical interest.

In Chapter I. boilers, in Chapter, II. wheels, frames and suspension, in Chapter III. motions are examined in detail, both as regards French and foreign practice, and the types most in favour are given prominence.

The theoretical and practical consideration connected with the construction and working of locomotives are dealt with in accordance with actual experience in Chapter IV., and V. is devoted to the determination of the power of locomotives and a review of the different method of using steam—simple, compound and super-heating and of the different types of locomotives.

It is a useful and well-written book by a locomotive engineer.

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Voids, Settlement and Weight of Crushed Stone. By IRA O. BAKER, Bulletin No. 23 of the University of Illinois Engineering Experiment Station, Urbana, Ill.

This bulletin gives the results of some experiments to determine the proportion of voids in crushed stone loaded by various methods in cars and in wagons, to find the amount of settlement during transportation in wagons and in cars also to obtain the relation between the weight of a unit of volume of the solid stone and that of the same volume of crushed stone immediately after being loaded in various ways, into cars and wagons, and also after being transported different distances. Crushed stone is usually nominally bought and sold by volume, but really by weight, since in ordinary commercial transactions the weight of a cubic yard of crushed stone is assumed and the number of yards in a shipment is obtained by dividing the total weight by the assumed weight of a cubic yard; and yet there seem to have been almost no experiments made to determine the actual weight of a cubic yard of crushed stone under any particular condition. Apparently the only experiments heretofore made upon this general subject are a few brief ones upon trap rock, conducted by Mr. McClintock, lately President of the Massachusetts Highway Commission. An account of his experiments is presented and discussed in this bulletin, but the main features are an elaborate series of tests upon crushed limestone from Chester, Joliet and Kankakee, all in Illinois. All the results are summarized in a table which gives for different sizes of crushed stone the co-efficients by which to multiply either the weight of a cubic foot of the solid stone (or its specific gravity) to get the weight of a cubic yard of the crushed stone at the crusher and also at the destination, for stone from the three different quarries. This elaborate table is summarized in the following statement: The mean co-efficient by which to multiply the weight of a cubic foot of solid limestone to obtain the weight of a cubic yard of crushed limestone is as follows:—

For ½in. screenings	15·5
For ½in. to 2in. stone	14·6
For 2in. to 3in. stone	15·2

For trap rock the corresponding co-efficients are as follows:—

For ½in. screenings	14·6
For ½in. to 1½in. stone	13·5
For 1½in. to 3in. stone	13·9

Mallet Articulated Compound Locomotives. Record No. 65 issued by the Baldwin Locomotive Works, Philadelphia, Pa.

This is a reprint of the paper by Mr. Grafton Greenough read before the Engineers' Club of Philadelphia in March last. It is well illustrated with photographic views and detail drawings and gives full particulars of the huge Mallet Articulated Compound Locomotives built by the Baldwin Locomotive Works for the Southern Pacific and other Railways.

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RECEIVED.

The Design for Typical Steel Bridges. An elementary course for Engineer Students and Draughtsmen. By W. CHASE THOMSON, M.Can.Soc.C.E.; Assistant Engineer, Dominion Bridge Co., Montreal. New York: The Engineering News Publishing Co.; London: Archibald Constable and Co., Ltd., 10, Orange Street, Leicester Square, W.C., 1908. [178 pp.; 8¼ by 8; price 8*s.* net.]

Locomotives a Vapeur. By JOSEPH NADAL, Assistant Chief Locomotive Engineer of the French State Railways. With 76 illustrations. Paris: Octave Doin, 8, Place de L'Odeón, 1908. [315 pp.; 7 by 4⅝; text in French; price 5 *frcs.*]

The Gas Engine Manual, a practical handbook of Gas Engine Construction and Management. By W. A. TOOKEY. Illustrated. London: Percival Marshall and Co., 26-28, Poppin's Court, Fleet Street, E.C. [186 pp.; 8⅝ by 5¼; price 3*s.* 6*d.*]

The Modern Steam Engine: Theory—Design—Construction—Use. A practical treatise. By JOHN RICHARDSON, M.Inst.C.E., M.Inst.M.E. With 300 illustrations. London: Archibald Constable and Co., Ltd., 10, Orange Street, Leicester Square, W.C. 1908. [384 pp.; 8½ by 5⅛; price 7*s.* 6*d.* net.]

Tables for Setting Out Curves, from 200 to 4,000 metres radius by tangential angles or offsets from tangents. By H. WILLIAMSON. London: E. and F. N. Spon, Ltd., 57, Haymarket. 1908. [50 pp.; 4⅞ by 3⅞; price 2*s.* net.]

English Prices with Russian Equivalents, calculated at 14 rates of exchange in roubles per pood, giving rate per lb. and equivalent per ton. By A. ADIASSEWICH. London: E. and F. N. Spon, Ltd., 57, Haymarket. 1908. [185 pp.; 3⅛ by 4; price 1*s.* net.]

The Application of Highly Superheated Steam to Locomotives, being a reprint from a series of articles appearing in *The Engineer.* By ROBT. GARBE. Edited by LESLIE S. ROBERTSON. With illustrations and tables. London: Crosby, Lockwood and Son, 7, Stationers' Hall Court, E.C. 1908. [77 pp.; 9⅝in. by 6in. and 7 folding plates; price, 7*s.* 6*d.*]

Flexible Metallic Tubing.

THE use of the tubing made by the United Flexible Metallic Tubing Co. has largely extended of recent years. It has the great advantage of being light, strong and very flexible, while at the same time it is not materially affected by heat or cold, and not at all by grease, which is the great enemy of rubber. For conveying oil or greasy liquids or gas it gives excellent results, and supports any ordinary internal pressure, while special qualities for hydraulics are made for high pressures up to 2,000 lbs. per sq. in., and for steam pressures up to 300 lbs. per sq. in. It is made in a wide range of diameters, as may be seen from the company's show in the Machinery Hall at the Franco-British Exhibition, and of which the annexed illustration is a view.

Roofs —IX.*

Compression Members.

THE calculation of the strength of a strut, column, or stanchion is by no means a simple matter if one is compelled to wade through text books and work out the complete theory. Further, although much has been written about the column, yet the data upon which all column formulæ are based are very much of an empirical nature and cannot by any means be accepted as exact and final, as in the case of beams, girders, and roof principals.

It is not quite obvious why columns should bend under end loading, although, of course, it is well known that they do. At what precise proportion of length to least diameter the column begins to fail by bending and not by direct compression is not a matter of certainty, but it is generally understood that a proportion of 20 for wood, 10 for wrought iron, and 5 for cast iron, for the length of column over the least diameter, is the limit at which the member becomes a "long" column, and when bending instead of crushing under load may be anticipated.

The discussion that commenced in the technical Press immediately after the Quebec Bridge disaster and the recent paper by Mr. J. R. Worcester with the discussion before the Am.Soc.C.E., has shown that the question of column formulæ is still uncertain, especially with reference to full-size members of bridge trusses. One American journal states that "there is no theory or rational formula in existence by which either the elastic or ultimate carrying power of an ordinary bridge column can be computed." By this it may be understood that the column formulæ in use are based upon a too small size of specimen taken to the testing machine, as well as on a wrong and unusual proportion of length to least diameter.

Another reason for doubting these tests is that usually the tested column failed locally, say in the riveting or in the connections, and did not fail as a whole. This, of course, introduces the question of unsatisfactory design, or otherwise, and further complicates the matter, and suggests that the ultimate strength may coincide with the elastic limit in many cases where it should not. Many failure tests have shown that no sensible distortion occurred, proving that the design of a strut is of equal importance to its calculated strength, and that the results of such tests may be dangerously delusive, when used for other cases.

The classic experiments of Hodgkinson have proved that the mode of failure of cast iron struts with a length up to 4 or 5 times the diameter is the same, and that when the length exceeds this proportion the column bends. It was found that with the lesser length the fracture formed a wedge, or was shaped as a cone or pyramid at the ends of the specimen, splitting off the sides, the height being approximately 1½ times the diameter. It was also discovered that the tensile resistance to the compressive resistance of the metal was as 1 to 7 or 8, which, with 7 tons tensile strength, gives about 49 tons per sq. in. for the ultimate compressive resistance.

The experiments went on for long columns, and in the case of three such long columns, where the first had both ends rounded, the second one round end and one flat end, and the third both ends flat; then the relative strengths were as 1 :2 :3 nearly. It has since been discovered that the same properties, depending upon the condition of the ends, are also found in columns of wood, wrought iron and steel.

The standard text book of Stoney gives the strength of long, square or round columns as varying directly as the fourth power of the diameter, and inversely nearly as the square of the length, or to be exact, to the 1·865th power. The strength of similar columns varies as the squares of any lineal dimension of the cross section, or in other words, of the sectional areas; the weights vary as the cubes of the dimensions, and if the strength of long columns of similar section are the same whilst the length varies then the sectional areas vary as the lengths, and the weights vary as the squares of the lengths. Stoney also states that the strength of a column depends not so much upon the direct strength of the material of which the column consists as it does upon the co-efficient of elasticity, which, of course, is the measure of the stiffness and resistance to flexure of the material.

Again, a comparison has been made between taper columns and cylindrical columns, and if the larger diameter of the column is D_1 and the smaller D_2, whilst the diameter of the cylindrical column is D_3, it is found that the comparative strength of the two varies as $D_1^2\ D_2^2$ to D_3^4, which proves that if the columns are the same in other respects the cylindrical one is the stronger. It has also been proved in the comparison of a flanged column with a hollow cylindrical column of equal weight and, of course, equal sectional area, that the strength of the flanged section is only ¾ that of the circular section, whilst the proportion of the strength of a cruciform section is less than ½ that of the circular section, all other things remaining the same.

Again, the strength of a solid square cast iron column is half as much again as a solid round column of the same diameter, whilst it was found that solid square columns break in the direction of a diagonal drawn between any two of the corners, and for the same reason it may be said that the square section is the strongest form of a rectangular timber strut, a fact that will be evident when it is seen that the fraction $\frac{l}{d}$ or $\frac{l}{k}$ is the greatest in a square section, all other things being the same.

Hodgkinson found that the resistance of columns of a length of 30 diameters up to 120 diameters is as the 3·6th power of the diameter, and as the 1·7th power of the length, and from this the following formulæ were derived :—

for solid columns, $W = n\,D^{3\cdot6} \div l^{1\cdot7}$

for hollow ,, $W = n\,(D^{3\cdot6} - d^{3\cdot6}) \div l^{1\cdot7}$

when D is the external diameter in inches, d the internal diameter in inches, l the length in feet, W the breaking load in tons, and n a constant depending upon the condition of the fixing of the ends.

The following values of the constant n are given :—

Solid columns with flat ends	44·16
,, ,, ,, rounded ,, ...	14·9
Hollow ,, ,, flat ,, ...	44·34
,, ,, ,, rounded ,, ...	13·00

The use of the complex power of any number becomes, of course, a simple matter when a table of logarithms is available.

*The previous articles of this series appeared in the *Railway Engineer* as follows :—I., May, 1907; II., July, 1907; III., September, 1907; IV., October, 1907; V., December, 1907; VI., February, 1908; VII., April, 1908; VIII., June, 1908.

In the above case, however, the resistance is only that against the bending of the column, which is the measure of its strength; but if shorter columns are considered, which are of course assumed to also possess, together with the direct compressive strength, a certain flexibility; then the resistance is compounded both of compressive resistance and transverse resistance, and the preceding value of W is required to be modified by the formula—

$$W^1 = Wc \div (W \times \tfrac{3}{4}c),$$

where W^1 is the amended breaking load, and C the direct compressive resistance of the column (say the sectional area × 40 to 49 tons per sq. inch).

Of course if it is desired to keep to the same unit in the linear dimensions, that of feet or of inches, the constants in the formulæ must be modified accordingly. The same also with regard to the strength being required in pounds or cwts. instead of tons; and if it is necessary, or found more convenient, to give the result as a safe resistance instead of an ultimate or breaking resistance, then the constant n must be divided by the factor of safety desired in the work. Anglin recommends a factor of safety of from 6 to 10 for steady loads on cast iron columns, and 12 to 20 for vibratory loading.

It will be noted from the preceding formulæ that all the factors are constant except the factor $D \div l$, so that if this factor remains the same it does not matter what size or what length the column may be. This fact will be referred to again later on. Another important factor in the strength of the column or strut is the manner in which the ends are fixed, whether rigidly connected to surrounding work, flat bedded, round bedded, or fastened to pins that will allow the strut to move, say, in one direction. So, therefore, if the condition of the fixing of the ends is known, and the proportion of $l \div d$ or $l \div k$, nothing else is of any consequence so far as the theory of calculation goes.

Hodgkinson gives the following formulæ with regard to the strength of timber struts or columns where the length exceeds 30 diameters, and where both ends are flat and well bedded :—

Long square columns of dry Dantzic oak :

$$W = 10{\cdot}95 \ d^4 \div l^2,$$

long square columns of dry red deal :

$$W = 7{\cdot}80 \ d^4 \div l^2,$$

long square columns of dry French oak :

$$W = 6{\cdot}90 \ d^4 \div l^2.$$

Where W is the breaking weight in tons, d the breadth in inches, and l the length in feet.

Where the length of the timber column is less than 30 diameters the result of the above calculation is again to be modified by the same formula as in the case of the cast iron column previously given, that is :

$$W^1 = Wc \div (W + \tfrac{3}{4}c).$$

When a strut or stanchion of this rectangular section is of oblong shape the least diameter is taken in the formula, thus if the long dimension is twice the shorter dimension, then the result as found above is to be modified by a multiplication of 2, or, in other words, by the ratio of the longer to the shorter dimension.

Euler's formula for elastic bending is as follows :—

Crippling load $= \pi^2 \ EI \div l^2$ for pin-ended struts,

where E is the modulus of elasticity of the material, I the Moment of Inertia, and l the length of the column or strut.

It may however be expressed to suit all possible cases by

$$P = n \pi^2 \ EI \div l^2$$

where n is a constant depending upon the condition of the attachment of the ends of the strut.

The value of this constant as given by Ewing is:

Both ends round	= 1
Both ends fixed in direction and position	= 4
,, ,, ,, ,, ,, one end only fixed in position	= 1
,, ,, ,, ,, position, one end fixed in direction	= $2\tfrac{1}{4}$
One end fixed in direction, the other end round and free to move sideways	= $\tfrac{1}{4}$

Taking the first state of the formula,

$$\text{Crippling load} = \pi^2 \ EI \div l^2$$

and taking E as 12,800 tons per square inch, and allowing a factor of safety of 5, the safe pressure per square inch becomes :

$$\text{Permissible stress per square inch} = 3{\cdot}1416^2 \times 12800 \times I \div 5l^2 = 25260 I \div l^2$$

or introducing the radius of gyration, which is $r^2 = I \div A$, we have $25260 \ I \div l^2 \ A = 25260 \ r^2 \div l^2$ for pin ended struts, a form where all other factors being constant there is, as in a previous case, the proportion $r^2 \div l^2$ to govern the result of the calculation, no matter what may be the linear dimensions of the column, and it is only necessary to introduce the constant n to suit the condition of end fixing.

Euler's formula, however, only applies in the case of very long columns that bend under the load before the limit of elasticity of the material is reached. Lineham says that the formula does not include any consideration of the compressive stress on the material, but gives only the load which will produce neutral equilibrium in the bending of a long bar, and "even does this imperfectly, for when a bar is subjected to both direct and bending stresses the neutral axis no longer passes through the centre of gravity of the section."

Perhaps one of the simplest rules for the strength of columns is that deduced by Gordon from the experiments of Hodgkinson, and is :

$$t = f \div (1 + (a \div c)\ (l \div d)^2)$$

in which t = average thrust in tons per square inch on section of strut.

f = intensity of stress in tons per square inch due to thrust and flexure.

wrought iron = 18 tons per square inch.
mild steel = 26 ,, ,, ,, ,,
cast iron = 36 ,, ,, ,, ,,

a = constant depending on the condition of the ends

c = ,, ,, ,, shape of cross section and nature of material.

l = length in inches.

d = least diameter in inches,

the values of the constant a being as follows :

for both ends fixed = 1
for both ends pivoted = 4
for one end fixed and the other pivoted = 2·5
for one end fixed and the other free ... = 16

and the value of constant c :—

for rectangular or cylindrical bars of wrought iron or mild steel ... ... = 2500
for angle, tee, cross, channel, rolled joist, built sections generally... ... ... = 3500

Anglin says for solid rectangular columns of wrought iron:

$f = 16$ tons, $c = 3000$.

Unwin recommends for wrought iron struts of channel, L, T, + etc.:

$f = 19$ tons, $c = 900$.

Baker recommends for steel columns:

Solid rectangular pillars	mild steel	$f = 30$ tons	$c = 1400$
	strong ,,	$f = 51$,,	$c = 900$
Solid round pillars	mild steel	$f = 30$,,	$c = 2480$
	strong ,,	$f = 51$,,	$c = 1600$

Trantwine gives the following values:

f = good wrought iron	40000 lbs	(17·85 tons)
cast iron	80000 ,,	(35·71 ,,)
mild steel ·15% carbon	52000 ,,	(23·21 ,,)
hard steel ·36% carbon	83000 ,,	(37·05 ,,)
pine	5000 ,,	(2·23 ,,)

c = wrought iron, both ends flat 36000 to 40000
wrought iron, both ends hinged 18000 to 20000
wrought iron, one end fixed and one end hinged ... ... 24000 to 30000

For cast iron $\frac{1}{8}$ of these figures is used.
,, pine $\frac{1}{12}$ of these figures is used.

Greene gives the following for the constant $a \div c$:—

Ends fixed 1/250 for rectangular timber struts.
,, ,, 1/3000 ,, ,, wrought iron ,,
,, ,, 1/800 ,, cast iron

and where struts are jointed at their ends by pin connections, or are so narrow as to yield sideways at these points, $2a$ is to take the place of a; if one end is firmly fixed in direction while the other end is jointed $\frac{4}{3}a$ is to be used in place of a.

Rivington's Notes, Vol. IV., gives the following values of constants when using Gordon's formula (reducing from the figures given in the book with factor of safety of 4), to ultimate strength.

Constant f = timber 2·6 tons per square inch
wrought iron 16 tons ,, ,,
cast iron 32 ,, ,, ,,

Constant a = as above 1 : 4 : 2·5 for both ends fixed, both ends pivoted, and one end fixed and the other end pivoted.

Constant c = timber, rectangular and circular = 250
rectangular, circular, solid or hollow = 2500

wrought iron	L, T, +, I, square, channels back to back, channels	= 900
cast iron	circular solid	= 400
	,, hollow	= 800
	rectangular	= 533
	cross shaped	= 266

Clark gives figures different again (as follows when modified from the actual figures given in the book), and the same figures are given by Lineham.

thus for f = cast iron = 36 (Hodgkinson)
wrought iron = 16 for solid rectangular (Stoney)
,, ,, = 19 for L, T, +, channel (Unwin)
mild steel = 30 (Baker)
strong ,, = 51 (Baker)

and for c = cast iron
solid or hollow round = 400 (Hodgkinson)
,, ,, ,, rectangular = 500 (Hodgkinson)

wrought iron
solid rectangular = 3000 (Stoney)
for L, T, +, channel = 900 (Unwin)

mild steel
solid round = 1400 (Baker)
,, rectangular = 2480 (Baker)

strong steel
solid round = 900 (Baker)
,, rectangular = 1600 (Baker)

The Carnegie Steel Co. give the following for cast iron columns:—

		f	$a \div c$
round columns	square bearing	80000	$\frac{1}{800}$
	pin and square	,,	$\frac{3}{1600}$
	pin	,,	$\frac{1}{400}$
rectangular columns	square bearing	,,	$\frac{3}{3200}$
	pin and square	,,	$\frac{9}{6400}$
	pin	,,	$\frac{3}{1600}$

and suggest for columns of medium steel a factor of safety of 4 for quiescent loads as in buildings, and 5 for moving loads as in bridges.

They also give for seasoned rectangular wooden pillars:—

		f	$a \div c$
yellow pine (southern)	(1125 × 4)	4500	$\frac{1}{1100}$
white oak	(925 × 4)	3700	,,
white pine and spruce	(800 × 4)	3200	,,

and suggest a factor of safety of 4 for short columns and 5 for long columns, we presume under quiescent loading.

(To be continued.)

Saloon Carriages, Shanghai-Nanking Railway.

The Metropolitan Amalgamated Railway Carriage and Wagon Co., Ltd., recently completed at their Saltley Works, Birmingham, under the inspection of Sir John Wolfe Barry and Partners, two saloon carriages for the Shanghai-Nanking Railway, and of which the principal dimensions are: Lengths respectively over the corner pillars, 61-ft. $2\frac{1}{4}$-in. and 45-ft. $2\frac{1}{4}$-in.; lengths over the platforms, 61-ft. $1\frac{3}{4}$-in. and 52-ft. $1\frac{3}{4}$-in.; width, 10-ft; rail to top of roof, 13-ft. $11\frac{1}{2}$-in.; rail to floor, 4-ft. 5-in.; floor to under cant rail, 7-ft. 1-in.; wheel base, 47-ft. and 31-ft. respectively; wheel base of bogies, 9-ft.; diameter of wheels, 3-ft. $6\frac{1}{2}$-in.; journals, 9-in. by $4\frac{3}{4}$-in.; centre to centre of journals, 6-ft. 6-in.; gauge, 4-ft. $8\frac{1}{2}$-in.

The arrangement of both carriages is in many respects similar, each being complete in itself and comprising dining, sleeping, bathrooms, and lavatories, together with a kitchen and compartments for the use of attendants. The 52-ft. saloon, being intended for the use of the Railway Authorities, contains compartments for the exclusive accommodation of the Chief Officers of the Line.

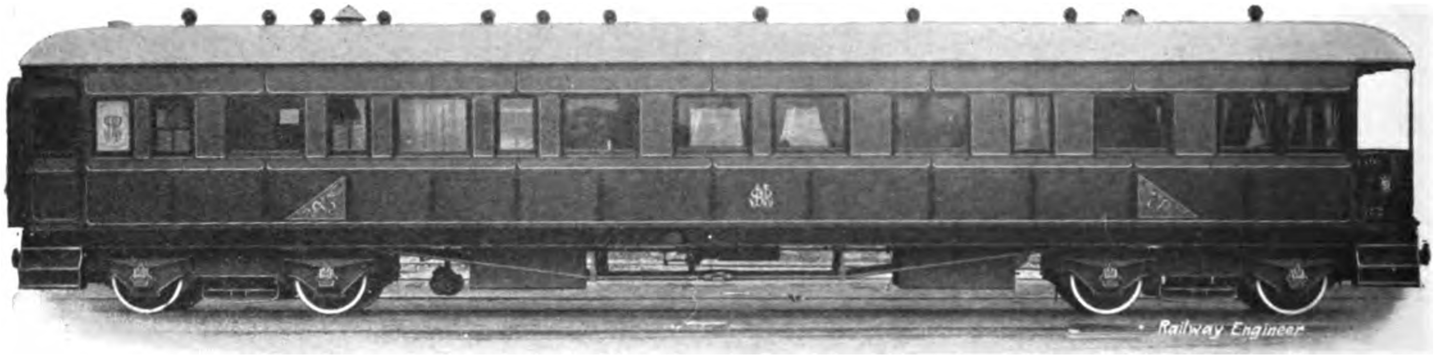
The general structure of the carriages is a combination of both English and foreign practice. The arrangements of the windows and the methods of bracing the body sides being similar to the usual methods employed on foreign cars, whilst the outside of the carriages is panelled and moulded after the manner of English stock. The outside panels are of planished steel, and the mouldings are of teak. The body framing is also of teak. The interior finish is on somewhat new lines for railway carriage work, bold in character, proportionate and thoroughly substantial.

The 68-ft. carriage is divided into dining, state-berth, observation, bath and bedrooms, lavatories, kitchen and attendants' compartment. The observation compartment is 6-ft. 7-in. long by the full width of the carriage. It has two windows each side, two at the end and a door 2-ft.6-in. wide, which gives access to an open platform, and has an upper panel of clear glass. The walls

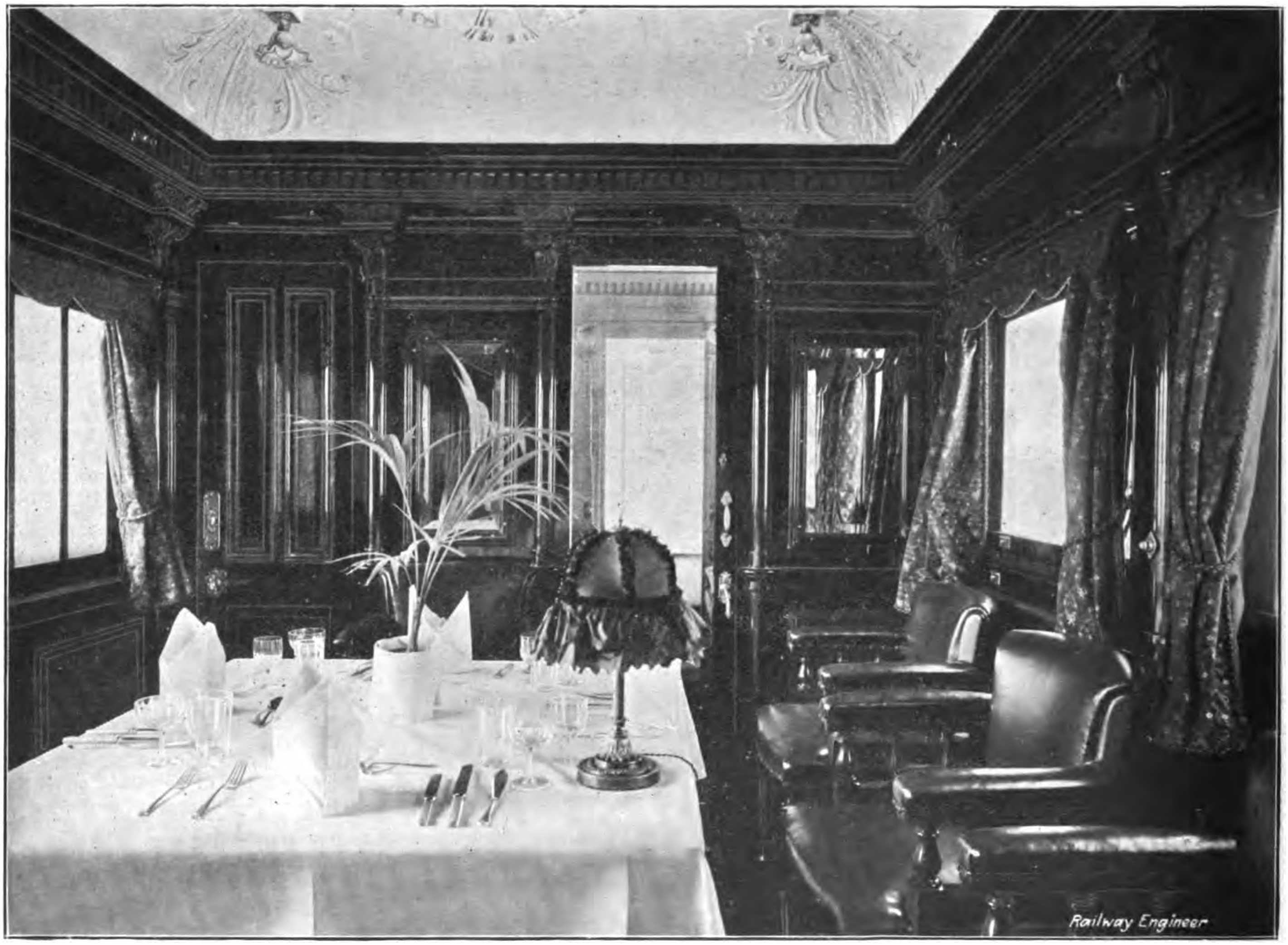
of the compartment are finished in polished quartered oak panels, oak facias and mouldings. The end partition is furnished with three bevelled mirrors, the middle one being of ornamental shape, and has fixed to it a small reading table, provided with an electric reading lamp, a water bottle and glass holder and a small drawer. Four chairs of polished oak, upholstered with red buffalo hide are provided; the floor is covered with a green Axminster carpet; green tapestry curtains are hung at the windows by ivory rings on metallic silver oxidised poles and brackets. A heavy cornice supports a dome roof of ornamented millboard panels, the upper part of the cove panels being secured with a moulded frame which also secures a centre panel having ornamental borders and corners of lincrusta. Attached to this centre panel is a large exhaust ventilator and a four-light electrolier. The compartment is provided with matchbox holder and ash tray, etc., and bell communication with the attendants is arranged. The open platform with which this compartment directly communicates is protected with wrought iron scroll work palisades, gates and standards, each gate and each section of the palisades being formed to receive a shield embossed with the monogram of the railway. The floor is covered with a non-slip rubber mat and steps to the ground are fitted with patent treads.

A corridor 2-ft. 3-in. wide, furnished in polished teak, connects the observation compartment and the dining room, passing the large lavatory and the state berth room.

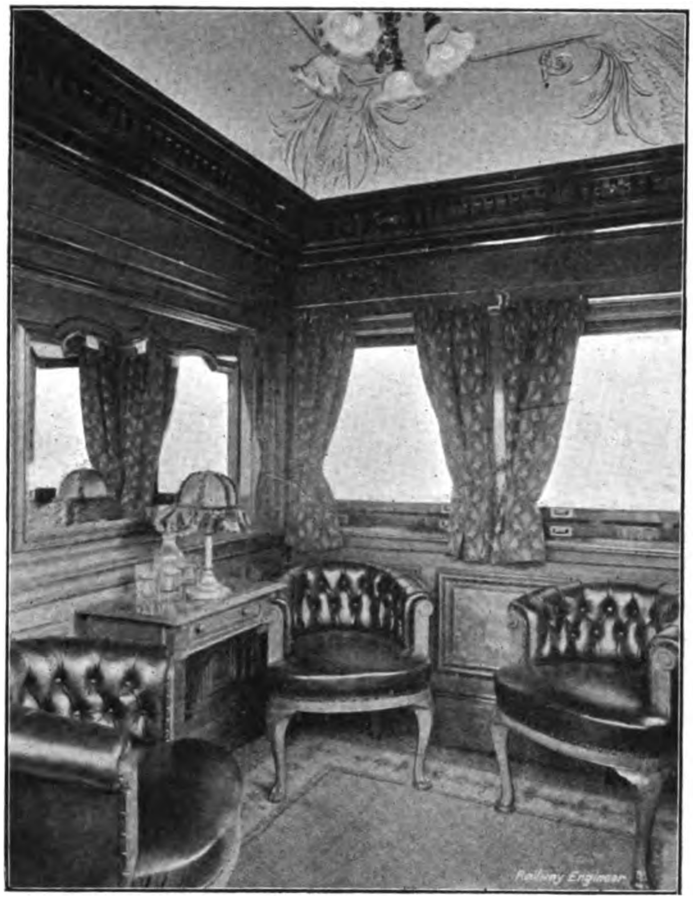
The dining room is approximately in the centre of the carriage. It is 10-ft. 11-in. long, and finished entirely in polished mahogany. Pilasters of semi-elliptical section, with massive carved capitals and carved trusses, support the cornice. Between the pilaster on each body side are arranged two large windows and on each partition two bevelled mirrors. This arrangement has given a noble and symmetrical appearance to the room.



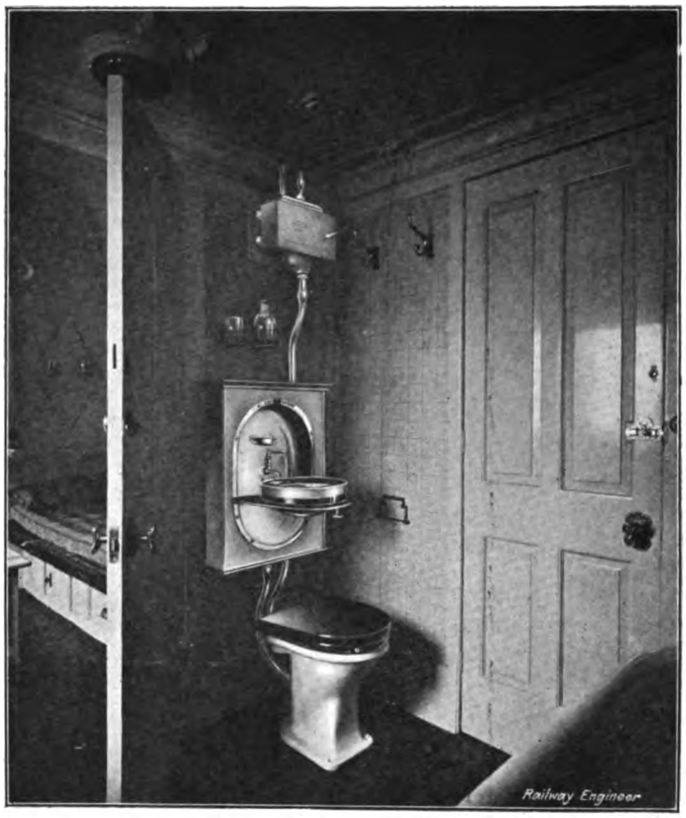
68ft. 0in. Saloon; Shanghai-Nanking Railway.



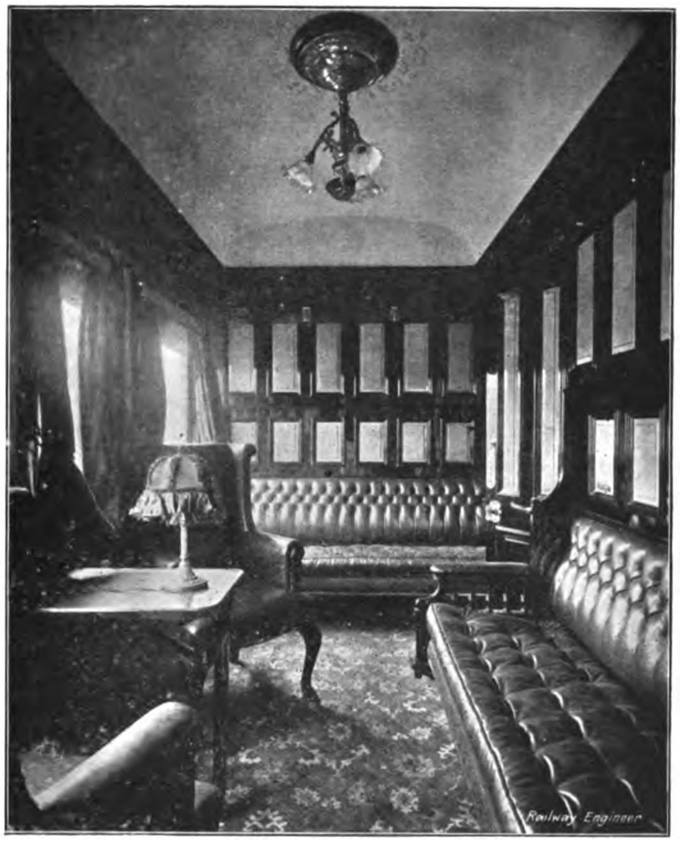
Dining Room: 68ft. 0in. Saloon; Shanghai-Nanking Railway.



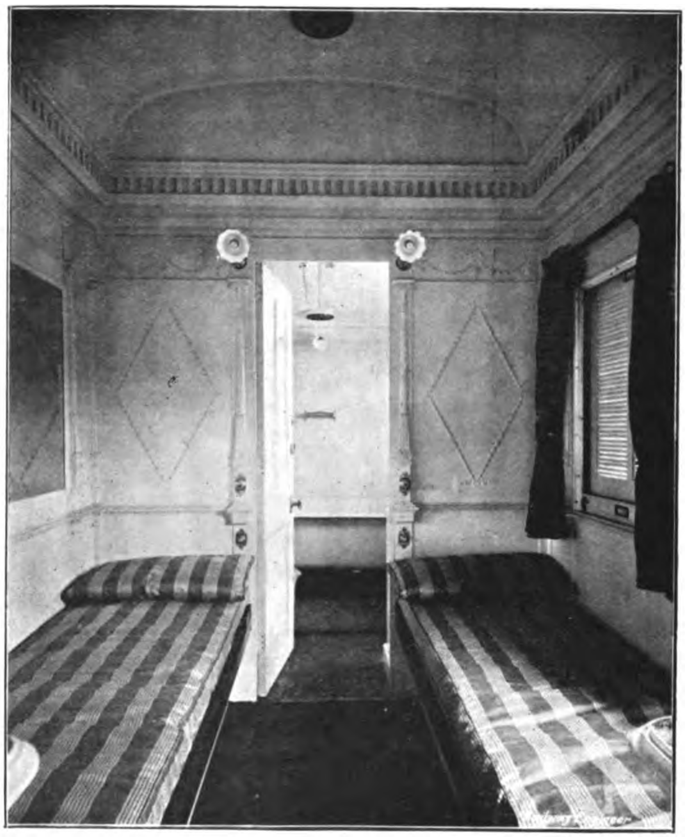
Observatory Compartment.



Bath Room.

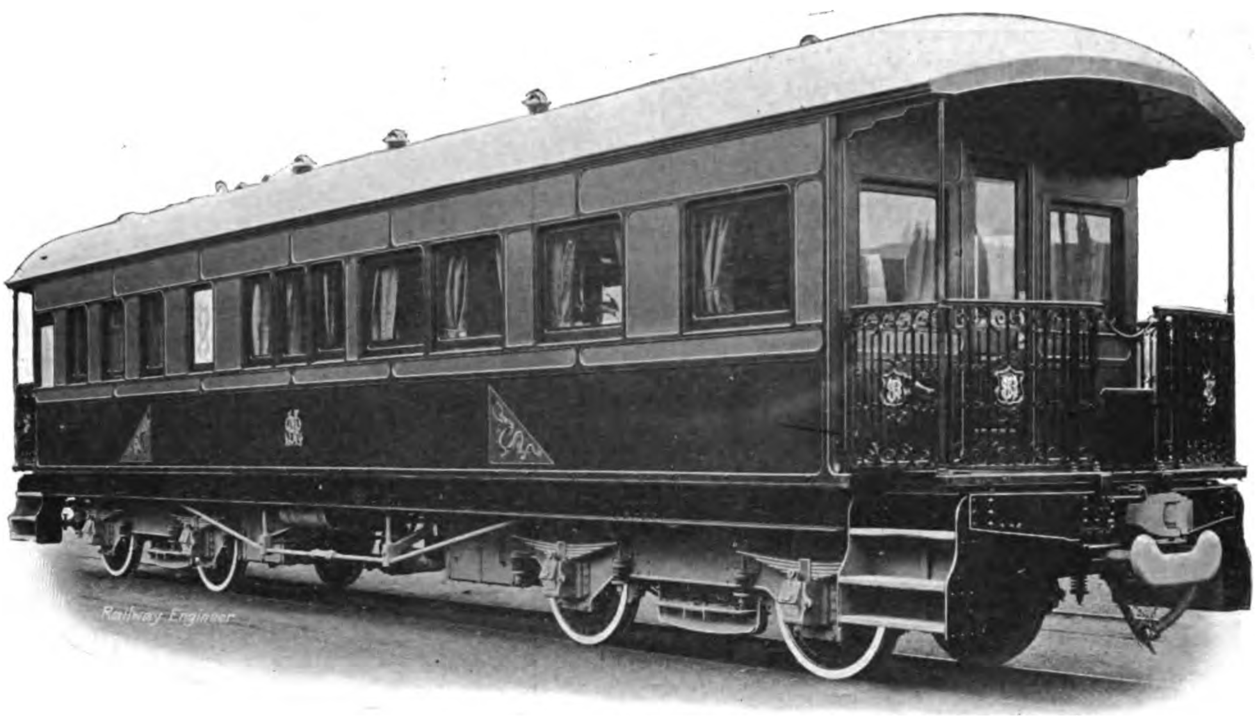


State Berth Room.



Bedroom.

68ft. oin. Saloon ; Shanghai-Nanking Railway.

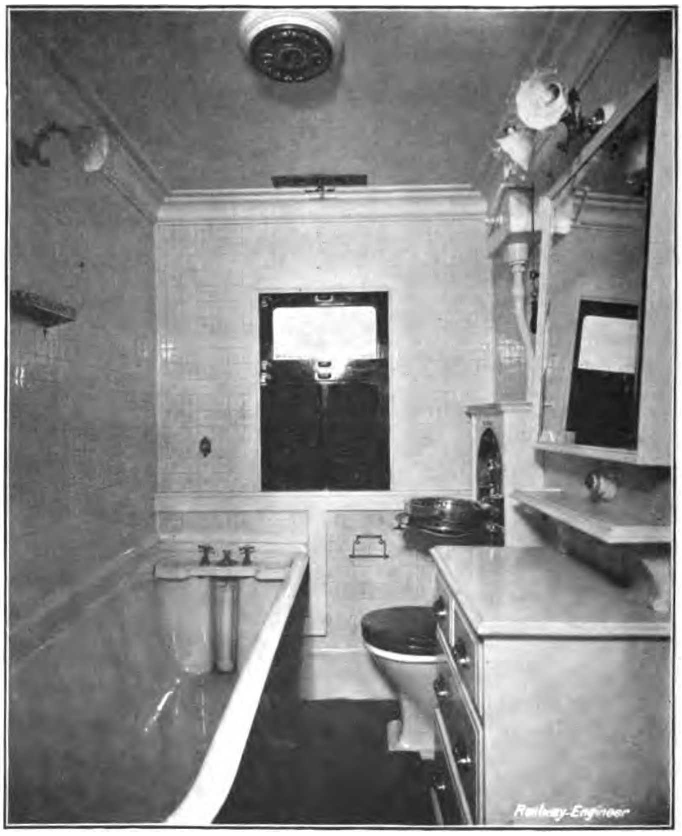


52ft. 0in. Saloon ; Shanghai-Nanking Railway.

The table and chairs are of polished mahogany, the chairs being upholstered with blue buffalo hide. Communication with the attendants is obtained by means of bell pushes fixed at the corner of the table, the legs of which are bored to receive the necessary wires. The floor is covered with a scarlet Axminster carpet and the windows are provided with scarlet curtains. A small glassware cupboard occupies a corner of the room. The ceiling is domed in a similar manner to that of the observation compartment, but in addition to the central electrolier, four small single light pendants are fixed at the corners of the centre panel frame. Two hinged doors open into corridors, one corridor, as before mentioned, leads to the lavatory and the observation compartment, the other leads to the bathroom, kitchen and attendants' compartment. Sliding doors, hung on "Crittall's" anti-friction bearings and guide at the bottom with noiseless shoes, communicate with the state-berth room and the bedroom. The door furniture and other fittings are of especial and artistic designs, usually incorporating the dragon; they are silver plated and oxidised, and were manufactured by Jas. Beresford and Sons, of Birmingham.

The state-berth room is 11-ft. 10-in. long by 6-ft. 10⅜-in. wide. It provides sleeping accommodation for 2 persons in lower berths and two in upper berths. The interior framing and the lower panels of this room are of polished American walnut, whilst the

Secretary's Room.



Bath Room.

52ft. 0in. Saloon ; Shanghai-Nanking Railway.

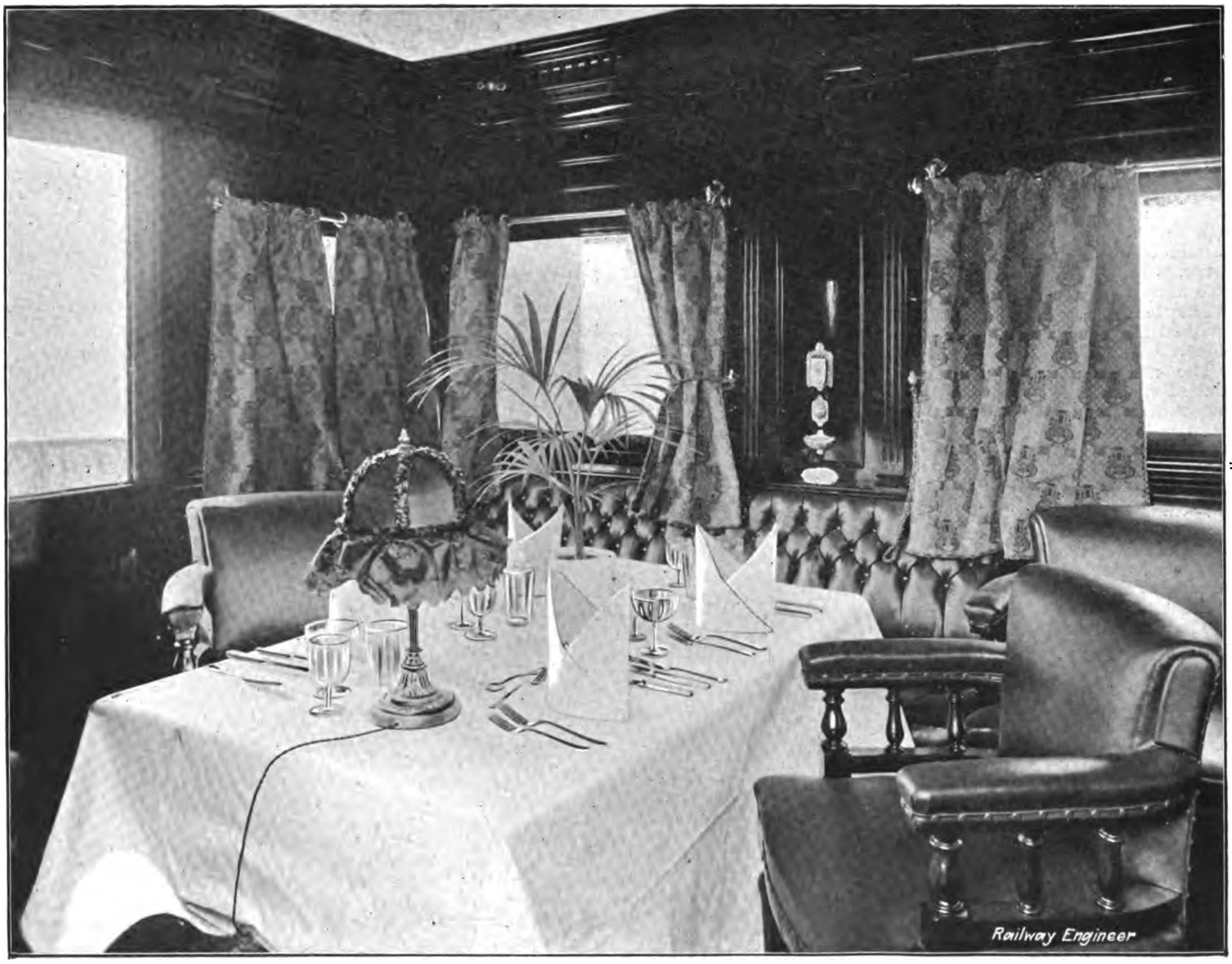
upper panels are of sycamore; all panels are fielded. As this room will be used for both day and night travelling, the lower berths are arranged as ordinary carriage seats, with the difference that their width can be increased for use as beds. The upper berths are panelled on the under side, and may be hinged up vertically against the partitions, each being secured with two strong ornamental spring catches; when in use the berths are supported with steel folding arms or lazytongs. Two chairs and a moveable table are provided.

The upholstery is of green buffalo hide, the curtains and carpet being green and scarlet. The ceiling is a large ornamental millboard panel of elliptical shape, carrying air extracting ventilators. The illumination of this room is by means of a large electrolier and a small table lamp, half-light switches are installed for night travelling.

The bedroom is 7-ft. long by 6-ft. 10⅞-in. wide. It is finished in pure white, and thus forming a striking contrast to the other compartments of the saloon. Two windows, each 2-ft. wide, are provided at the body side, and opposite these on the corridor partition are fixed two bevelled mirrors. Carved pilasters are arranged at the sides of the windows and mirrors, the corners of the room, and at the sides of the doorways. The walls are covered with stippled millboard panels, with lincrusta ornamentation. The beds are carried upon wire spring mattresses, and cupboards and drawers for bedding are arranged under the beds. At the foot of each bed a small table is fixed and water bottle and glass holders being provided, also electric bell pushes. Four single lamp brackets are carried at the tops of the pilasters on the transverse walls.

A hinged door opens into the bathroom, which is of the same dimensions as the bedroom. This room has a full-size bath, a folding lavatory basin, a hopper with flushing cistern, water bottle and glass holders, hat pegs, toilet and towel baskets, etc., and a small dressing table. The supply of hot water is obtained from a tank fixed at the side of the kitchen stove. The walls of the bathroom are covered with "Emdeca," pasted to a backing of ⅛-in. cork. All exposed woodwork is painted white. The large lavatory contains a filter and a large wardrobe in addition to the usual fittings. The walls are covered with "Emdeca" similar to the bathroom, and all woodwork is painted white. The water for lavatory and bathroom purposes is carried in tanks fixed above the corridor ceilings. Most of the lavatory fittings are of James Beresford and Sons' manufacture.

Installed in this saloon carriage and also in the smaller carriage is "Stones" system of combined heating and ventilating. High pressure steam from the locomotive is taken from the main heating pipe and conveyed through ½-in. pipes to two heating coils situated one on each side above the bathroom ceiling, ⅜-in. pipes being connected to these and carried through ducts at the sides of the carriage. A perforated zinc air collector is fixed on the top of the roof, the air collected, after being filtered by passing through a cocoanut fibre mat floating in a tank of water, enters tubes leading to the said duct containing the heating coils. Connecting each heating coil chamber is a 25 volts electrically driven motor, with fans which draw in purified air and force it over the heating coil and thence through the ducts to openings into the various rooms. The ducts are made partly of zinc and partly of wood, and being fixed behind the cornices they are so neatly hidden that the small silver oxidised handles which operate the shutters for regulating the intake of air are the only visible evidence of their presence. A regulating cock is provided between the main steam pipe and the heating coils, thus enabling air of any desired temperature to be driven along the ducts. The bathroom ceiling is arranged to give easy access to



Living Room, 52ft. 0in. Saloon Shanghai-Nanking Railway.

the motors, heating coils and air purifying bath, and the latter may be readily removed for cleansing or renewal.

The kitchen is 6-ft. 7½-in. long by 6-ft. 10¾-in. wide. It is provided with a coal burning stove, hot water tank, ice boxes, sink, draining rack and the usual culinary appliances. As precautions against fire the floor is covered with a steel plate and the partition at the back of the stove is double, being made of steel plates, lined with asbestos, with a space of ½-in. between them. The outer plate extends to within a few inches of the floor. The ceiling is lined with asbestos and sheeted with steel. The stove flue consists of two steel tubes carried to a cowl above the roof. Between the inner and outer tubes is a 2-in. air space. The ceiling of the kitchen is built in sections, as it has to be removed to give access to water tanks which are situated between it and the outer roof. The manner of supporting the tanks will admit of their easy removal in the event of repairs being required.

The attendant's compartment is 5-ft. 6¼-in. long, and contains a small lavatory compartment. It is provided with cushioned seats, an upper berth, a parcel rack and a moveable table.

The 52-ft. saloon carriage consists of a living room and secretary's, engineer's, bath, kitchen, servants' and lavatory compartments and platforms.

The living room (11-ft. 3¾-in. long) is at one end of the carriage, end windows being provided. A hinged door connects an open platform. The furniture of this compartment comprises a couch (which may be extended for use as a lounge), a dining table, four upholstered chairs and a mahogany sideboard; the latter covers the whole of the partition which separates this room from the other compartments and is fitted with cupboards, drawers and bevelled mirrors. The entire wood finishing is of polished mahogany, noticeable features being the fluted pilasters with carved double capitals, the various forms of mouldings and the character of the cornice. The upholstery is of green buffalo hide, and the Axminster carpet and tapestry curtains being of scarlet. The ceiling is similar in design and ornamentation to that of the dining room of the other saloon carriage. Access to the two next compartments is by a corridor, finished in polished oak.

These compartments are for the personal use of the chief officers of the line. Each compartment contains a roll-top desk, an office chair and an assistant's table and stool. One compartment is finished in light figured oak, the other in walnut and sycamore. Both compartments are provided with upholstered seats, 6-ft. 10-in. long, and convertible into sleeping berths. The Walnut and sycamore compartment is also provided with an upper berth similar in construction to those of the state berth room. In the oak compartment is fixed a cabinet lavatory and a bevelled mirror. Both compartments are lighted up with electroliers and table lamps.

The bathroom, kitchen, and servants' compartments are arranged and finished in the same manner as those of the 68-ft. saloon.

The metal furniture used throughout the saloons is silver oxidised and relieved, except that in the servants' and kitchen compartments, this being copper oxidised and relieved.

All ceilings are painted pure white and the floors of all compartments and of the corridors are covered with "Kork Lino."

To muffle the transmission of sound through the floors, these are constructed of two layers of boards placed 1¾-in. apart, the intervening space being filled with well rammed teak sawdust.

Precautions have been taken to prevent the entry of dust through the window openings by means of gauze wire and Venetian frames. The drop windows and the Venetian frames are supported by "Laycock's" patent window balancers.

Stone and Co.'s system of electric lighting is installed.

The outside panels of the saloons are painted, the upper ones in Chinese yellow and the lower ones are grained in a very true representation of teak. These panels carry transfers of the monogram of the railway and also the arms of China.

The saloons, being too large to be transhipped to China complete, were made in such a manner as to be taken to pieces in sections, each side in three parts and each roof and floor in two. Every precaution was taken to minimise the effects of the long sea voyage, all being packed in zinc-lined cases, the dimensions of some of these exceeding 38-ft. 6-in. × 11-ft. × 3-ft. 6-in., and weighing nearly 6 tons.

Under frames.—These are constructed of rolled sections, connected in the usual manner with knees and gusset plates, and stiffened by diagonal bracing. The solebars and longitudinals are of 10 × 4 × 7/16 channels, jointed at the middle to facilitate transport, the said joints being suitably strengthened with double cover plates, one of each being flanged to fit in the trough of the channel. The bolsters are built up of plates and angles, being increased to 12in. deep in the middle to take the ends of the longitudinals, which are 12 × 4 × 7/16 channels, which go through to headstocks of the same section, bent to the shape of the end of the vestibule and platforms. The frames are set back at the ends under the platform to accommodate the side steps, and so bring them within the loading gauge. The end longitudinals are arranged to take the standard type of draw and buffing gear, which consists of a central type of Automatic coupler, combined with a spring bumping plate, situated below the coupler. The lengths over the headstocks are 68-ft. and 52-ft. respectively, both frames being 9-ft. 5-in. wide over solebars, which have queen post trusses, the rods being 1⅜in. diam. The dynamo and accumulator boxes are suspended in the usual manner from the crossbars.

Bogies.—The bogies are built up of plates and angles, and follow the standard practice of the railway co., except that the bolster springs are fitted with McCord's patent damping arrangement. In addition to the bolster springs they are provided with laminated springs over each axle-box, suspended through auxiliary bearing springs of spiral pattern.

The cars are equipped with the Westinghouse air brake, provided with the improved type of triple valve. The brake blocks act on both sides of all wheels.

The weight of the carriages complete in running order is 43 tons 4 cwt. 2 qrs. and 38 tons 4 cwt. 1 qr., respectively.

Egyptian State Railways, 1907.

The Annual Report of the General Manager, Col. G. B. Macauley, upon the working of the Egyptian State Railways and Telegraphs for the year 1907 states that:—

The gross receipts of the railways were, L.E. 3,565,040, and the working expenses were L.E. 1,953,197, and the net receipts L.E. 1,611,843, which shows an increase of L.E. 193,786, compared with 1906.

The working expenses were 54.79 per cent. of gross earnings (56.47 per cent. in 1906), but this percentage has only been attained by the extraordinarily favourable conditions of traffic which prevailed, and it will not be possible to continue to work at such a percentage.

The passengers carried in 1907 increased by 3,500,000, or 15 per cent., but the limit of the capacity of the existing trains has been reached and greater increase in coaching kilometrage may be expected in the immediate future. The total coaching earnings were L.E. 1,718,421—an increase of L.E. 231,490 or 15.6 per cent. over 1906.

The ordinary merchandise carried increased by 194,000 tons, and the number of live stock by 86,000.

Service transports decreased by 200,000 tons.

The total earnings from goods traffic amount to L.E. 1,808,834—an increase of L.E. 59,603 over 1906.

Coaching earnings were 48.20, goods, 50.74, and sundry 1.06 per cent. of total receipts.

	1906	1907
Earnings per kilom. open	L.E. 1.408	L.E. 1.536
Earnings per train kilom.	,, 0.216	,, 0.228
Expenses per train kilom.	,, 0.122	,, 0.125
Net earnings per train kilom. ...	,, 0.094	,, 0.103

The net earnings are still increasing more rapidly than the interest on capital expended:—

	Capital value.	Net earnings.	% on Capital.
1902	L.E. 20,383,000	L.E. 1,059,000	5.19
1906	,, 23,200,000	,, 1,418,000	6.11
1907	,, 24,359,000	,, 1,611,843	6.61

The capital values are those fixed arbitrarily by Lord Farrer's Commission.

A sum of L.E. 868,000 was expended on capital works in 1907.

The price of coal has risen considerably and there are prospects of a further rise. Experiments will be made to see if "North Country" coal cannot be used satisfactorily instead of Welsh coal; it is considerably cheaper and is largely used elsewhere.

The Chief Mechanical Engineer's report shows a decrease of 22 in the number of engines during 1907, but 40 new engines ordered were delivered in January, 1908. The average age of locomotives in 1907 was 12 years, being the same as in 1906. The coal consumed by the engines has averaged 11.2 kilogs. per kilom.; in 1906 the average was 10.4. Trains were heavier. During the year 72 new coaching vehicles and 853 new wagons were put into service.

A new erecting shop at Boulac was constructed; 112 kiloms. of new line have been relaid. 167 kiloms. of line have been ballasted. The average number of platelayers per kilom. of line maintained has been 0.898.

The cost of labour on upkeep, inclusive of gangers and

inspectors, has been L.E. 22.660 mills. per kilom.

The strengthening of the bridge at Benha has been finished. The execution of this work under traffic without any mishap reflects great credit on the Bridge Department. The bridge over the Nile at Zifteh has been finished and the bridge over the Nile near the Barrage is well in hand. The new Gabbari Road-Bridge has been opened to traffic. The only bridge contract of any importance let during the year is that for a bridge over the Kocheicha Escape. The price was L.E. 52,348, and the successful tender was sent in by Baume and Marpent, Belgium, their offer being the cheapest. 516 new signal levers were fixed and 300 brought into use. 73 new tube wells have been sunk, and pumps fitted.

The Principal Medical Officer reports that out of 9,351 candidates examined, 54 per cent. were found fit for service.

The Indemnity Committee on cases of injury is working well. A classification of injuries on duty is required in order to regulate the decisions of the various Departmental Committees of Enquiry. Out of 200 cases dealt with, only 11 have refused to accept the Committee's decision.

The stores of the locomotive and signalling departments have now been transferred to the Central Stores Department.

Permanent Way.—II.*

Fig. 5 shows the standard road-bed for single and double lines of the Pennsylvania RR., the upper illustrations being for a cutting and the lower for embankments. There is a depth of 6in. of ballast under the sleeper in the centre line for double lines and of 8in. for single lines. The top of the Formation has a slope of ¼in. per foot from the centre line towards the sides, so that the ballast has a depth of 8in. under the outer side of the sleepers. The ballast is levelled with the top of the sleepers at the centre line and has a batter of 1 in 2 at the side. On single lines 2,629 cub-yds. of stone ballast are used per mile, 3,127 cub-yds. on double lines and 11,632 cub-yds. on four lines of way. Ashes are used on newly-made ground until it is settled.

* No. I. appeared in August, 1908, issue.

Fig. 6 gives the details of the Philadelphia and Reading RR.—on an embankment on the straight; in a cutting on the straight; and in a cutting on a curve with a left-hand radius. The top of Formation is level. The ballast is laid to a depth of 15in. from the top of the sleeper and 7in. or 8in. below the bottom of the sleeper. On curves these dimensions apply to the depth under the sleeper on the low-rail side. Ballast is laid to within 1in. of the top of the sleeper and the ends are curved and extend to 2ft. 6in. beyond the outer end of the sleeper. Broken stone or furnace slag is generally used, but on newly-made ground cinders until it is properly settled.

Fig. 7 illustrates the road-bed used on the Wabash RR. for class A track, *i.e.* the best. Details are given of double and single lines and on an embankment in the upper illustrations and for a cutting in the lower. The top of the Formation is level and ballast is laid to a depth of 18in. from the top, and 12in. from the bottom of the sleeper. The ballast is levelled off with the top of the sleeper and the end rounded off and extending to 4ft. beyond the outer end of the sleeper instead of 2ft. 9in. and 2ft. 6in. as with the Penn. and P. and R. just noticed. At the edge of the Formation there is a path of sods 12in. wide. For single tracks 0·70 cub-yds. of ballast per lin. ft. is used and 1·37 for double tracks.

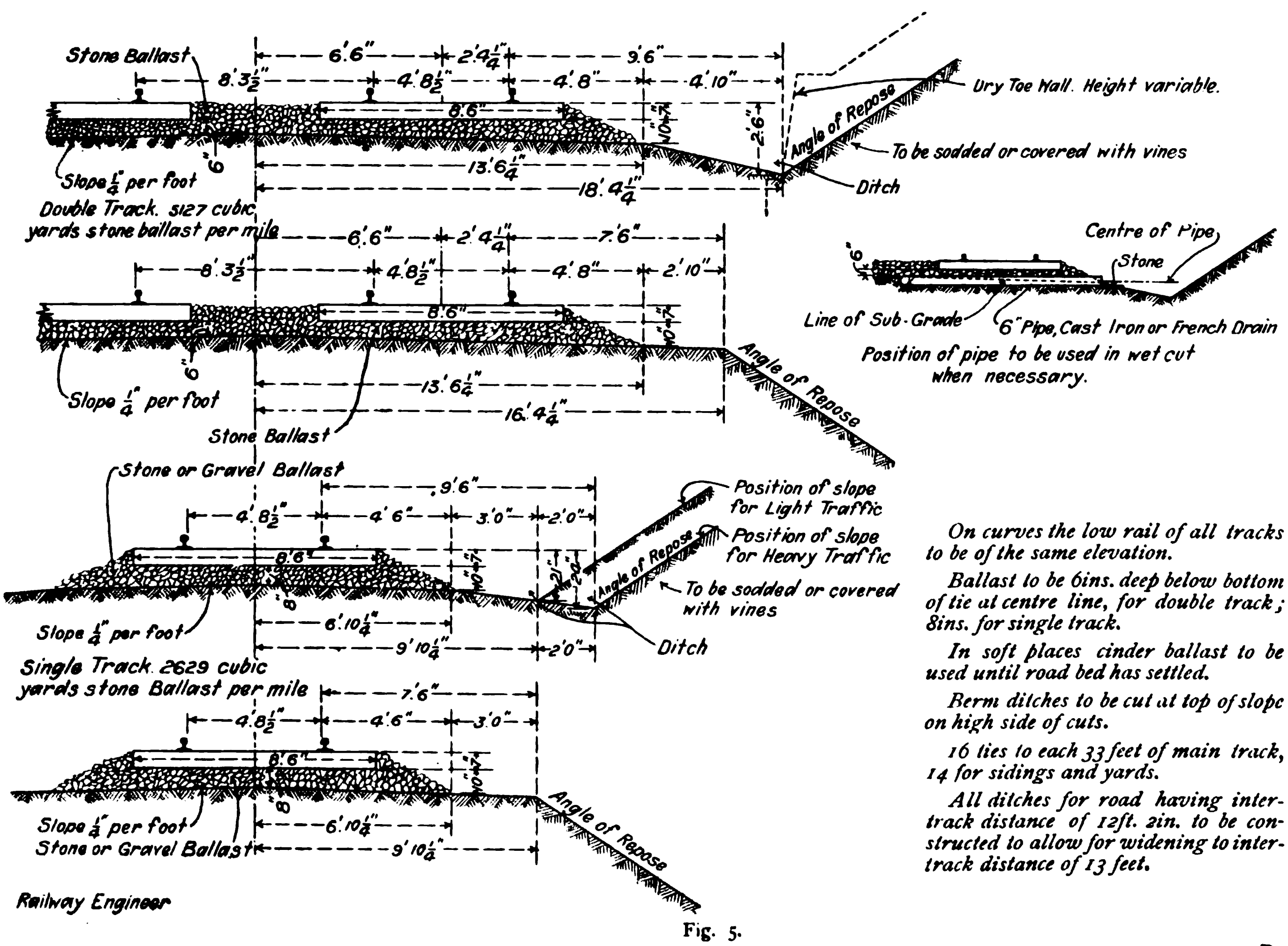
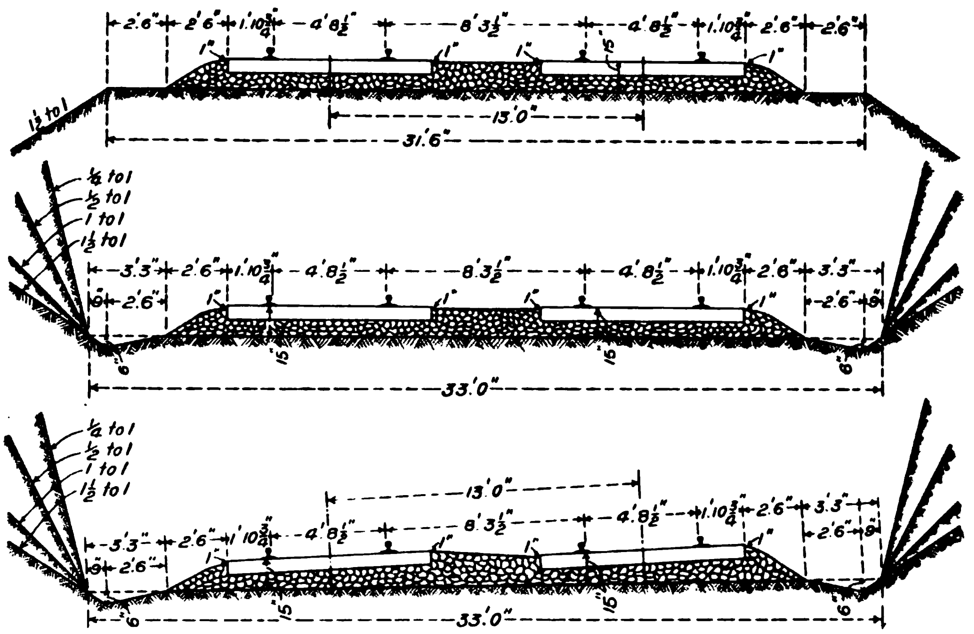


Fig. 5.

Fig. 8 illustrates the formation adopted on the Lehigh Valley RR., the upper drawing being for a double line on a curve and the lower for a double line on the straight. These sections are shown on the extreme left for broken stones or good furnace slag; in the centre good clean gravel or good cinders and on the extreme right poor gravel or clay. The top



Slopes: Cut in solid rock, ¼ to 1; Cut in broken stratified rock, ½ to 1; Cut in stiff earth, 1 to 1; Cut in loose earth, 1½ to 1.

Fig. 6.

of Formation has a slope from the centre line of 5in. in 16ft., the top of the sleeper being 14in. above the top of Formation on the centre line and 19in. at the edges of the Formation. The ballast is 16in. deep from the top of the sleeper in the centre of the latter and 9in. deep from the bottom of the sleeper. It is laid within ½in. of the top of the sleeper and at the outer end the top of the ballast is level for 6in and then tapers down 18½in. in 21in. The space between the tracks is treated differently according to the material used. With broken stone or good cinders it is kept practically levelled, but is hollowed, as shown, where gravel is used. Where clay is employed the ends of the sleepers are quite bare.

The top of the Formation on the Southern Pacific system of the Harriman lines is level for the length below the sleeper and has a slope of 6 to 1 thence to the toe of the bank or top of the embankment. For single lines the Formation is 16ft. for embankments and, generally, 16ft. for cuttings, but 18ft. is preferred for the latter, especially in regions where the rainfall is heavy. The ballast is 15in. deep from the top of the sleeper in the centre and is level with the top of the sleeper. At the ends it is level for 6in. and 18in. deep and then tapers down to a point 4ft. 2in. from the rail for a sleeper 8ft. long and 4ft. 8in. for a 9ft. sleeper. The instructions to the permanent-way men are that the toe-line is to be marked by a line of stones of a size that will pass through a ring 2½-in. diameter or larger, but where the ballast material does not contain a sufficient quantity of stones of this size the toe of the ballast must be neatly shovel-lined. These instructions also say that the rules as to ballasting should receive closest attention, as there is no one matter that contributes more to neatness and economy in maintenance of the track, and that, in repairing, great care should be exercised to prevent mixing earth or clay with ballast. In renewing sleepers the ballast beds must be loosened and the sleeper tamped to a firm bearing. This must never be attempted on the old bed, *i.e.*, the Formation, as the general surface of the rails is thereby raised.

On the Southern RR. the Formation is curved and is 20ft. wide for a single line in a cutting and 16ft. wide on an embankment. On the centre-line the ballast is laid to a depth of 8in. under the sleeper. The ends of the sleeper are not covered but the ballast is tapered off from under the rails at an angle of 2 to 1. Broken stone, slag or clean angular gravel is used. The stone has to pass through a 2in. ring and be as uniform as possible.

Before leaving the question of Formation and Bottom Ballast it should be remarked that the foundation for the permanent way of British railways is as it has been "for generations," and whilst rolling-stock has increased in weight and trains run at higher speed, no change has been made in the sub-structure for the sleepers, chairs and rails. Some companies are, at the present moment, turning their attention to this question. On one railway the road-bed is being altered as shown by fig. 9. The cut at the side is being carried further inwards and tapered off from a point under the rail as shown. Under the Bottom Ballast is also a bed of clinkers and the widened ditch will be filled with stones.

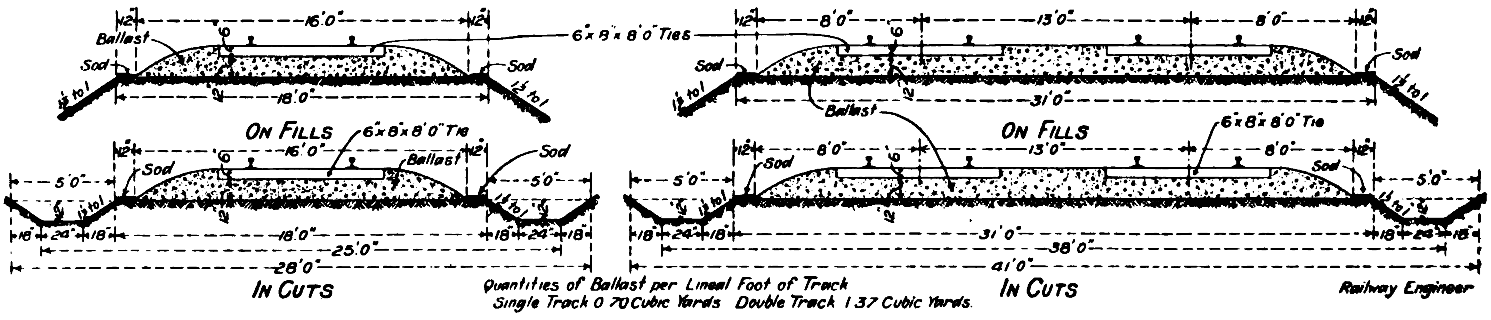


Fig. 7.

One benefit of this will be that in clayey districts, such as in London, the pounding of a passing train will not cause the moisture to ooze out as present.

Material for Top Ballast.

The best material for top ballast is basalt, close grained granite, trap, limestone or blast furnace slag. These do not crush under the weight of the train, but, the pieces being angular, the edges bite and they support each other as bricks in a wall. Consequently, the sleepers do not rock as a train passes. They do not hold water, so that the line is well drained, water readily percolating through. If no loam or dirt get mixed with the stone ballast when it is being laid on the line weeds will not grow, but if they do get in they are harder to remove from stone ballast than from gravel. Stone is harder to pack and work than gravel, and it gives a tidier appearance, and, being practically dustless, it furnishes greater comfort to the traveller and inflicts less injury in the machinery. The weather has less effect on stone ballast than on gravel or clinker ballast, and it is less liable to "heave" after a frost. Most gravel ballast is of flints which fly and the chippings become mud in time and ooze out. A large quantity of Thames ballast is used. This is round and therefore will not grip as granite does and, consequently, a roll is set up to the engine and train when passing. All classes of gravel are dirty too. Clinker ballast is, like gravel, easily worked and often cheap. Very little cinder (clinker) ballast is now used except where the line has continually to be packed owing to colliery settlements, and in such places there is no alternative. The objections to cinder ballast are the dust that comes from it and, there being no interstices for the water to get away, difficult drainage. But the principal objection is that, since the introduction of mechanical stokers, cinder (clinker) ballast is not what it was 10 or 15 years and more ago. It may here be opportunely remarked that furnace slag is also not so good as it used to be, changes having been made in the manufacture of steel, whereby the waste is now of inferior quality.

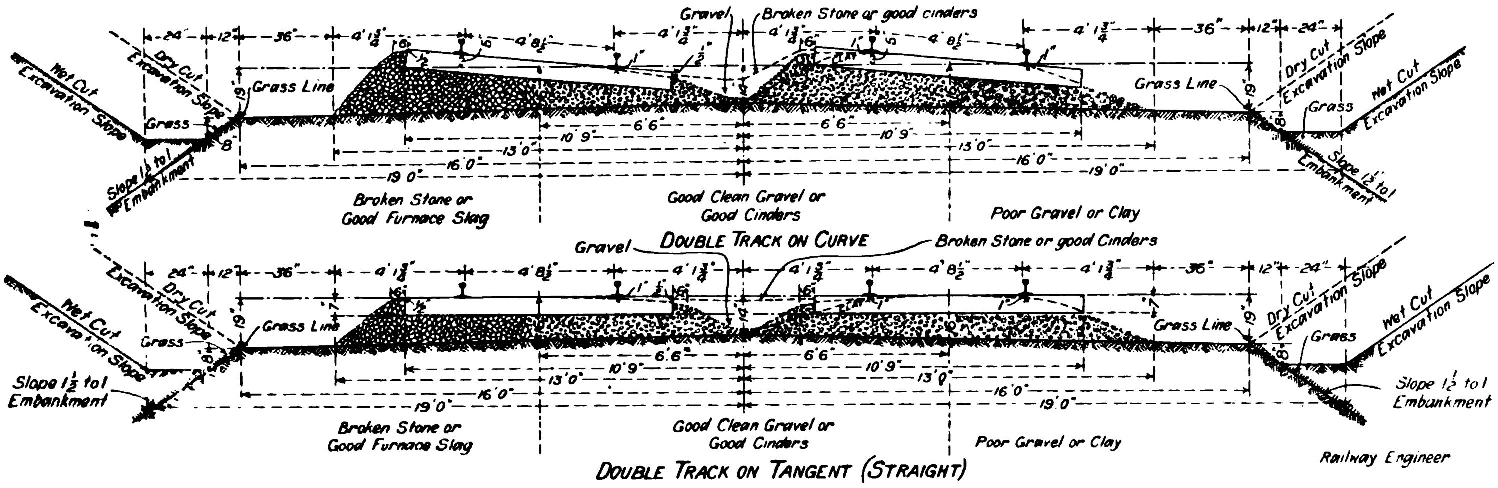


Fig. 8.

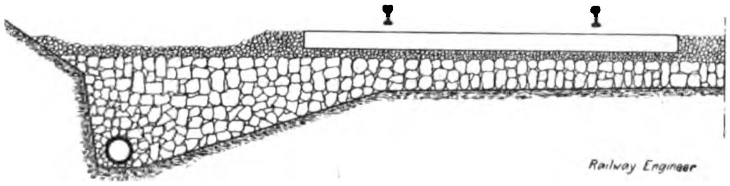


Fig. 9.

Most of the companies' supplies, however, come from blast furnaces, although a little is supplied from quarries belonging to railway companies, *e.g.*, Goodwick and Tenby on the G. Western R. Ballast crushing plants are erected at the furnaces and quarries. Some of these plants are the property of the railway companies who either crush the stone themselves or hire the plant to private persons who do the crushing and supply the stone by contract at a price which covers the hire of the machinery. Or the plant belongs to contractors.

The G. Western R. have a crushing plant at Goodwick and Fishguard where the smaller stone obtained from the excavations for the harbour works there was broken up for ballast. It is one of the Allis-Chalmers gyratory machines which breaks the rock to a 2in. size, the ¾in. chippings and sand being turned into a concrete mixer. The 2in. size fall into large bins, capable of holding 400 tons and thence they are loaded into hopper wagons. The wagons can be loaded with 90 tons of ballast in 20 minutes and the plant is capable of supplying 1,000 cub-yds. of ballast per week.

In America, where distances between towns and inhabited places generally are, as a rule, very great, it is a frequent practice to have stone laid by the side of the track and for a portable stone crusher to go over the line. Into this the stone is thrown, broken up and placed on the track. In that country the size of stone generally used is that which will pass through a 2in. ring, but some permanent way men prefer a larger size—2½in., 3in. and even 3½ins. Other like a smaller size—1½in., 1in. and as small as ¾in.

British companies generally specify that top ballast shall be of material that will pass through a ring 2in. diameter. The L. and North Western R., as mentioned last month, specify that 90 per cent. must pass through a ring 1½in. diameter inside but not through a ring ½in. internal diameter, and that not more than 1 per cent. must be capable of passing through a sieve ¼in. mesh. The Great Northern demand 1¼in. to ¾in. in size and the Midland not bigger than 2¼in. and not less than ¾in.

(To be continued.)

Combustion Processes in English Locomotive Fire-Boxes.*

Introduction.—Ever since the signal triumph of Stephenson''s "Rocket" at the Rainhill trials in 1829 the exhaust steam from the cylinders has been utilised for increasing the draught in the fire-box. The employment of the "steam-blast" for accelerating combustion, so as to render the rapid production of steam possible, has been universal so far as locomotives are concerned, but in the majority of other boilers the steam-blast has been replaced by some form of forced or induced draught by means of a fan. The employment of the steam-blast on the locomotive where space is limited has the great advantage of simplicity, although, on account of its intermittent character and its dependence upon speed, etc., it leaves much to be desired as a means of supplying air to the fire-box. Many investigations of the efficiency of combustion taking place in stationary, marine, or other boilers, under both natural and forced draught, have been made, but few, if any, have been made upon the products of combustion of locomotives during actual running, although the charge of emitting poisonous gases was made against the locomotive practically at the time of its first successful introduction.

The following investigation was undertaken for the purpose of determining :—

(1) The efficiency of the combustion of the fuel.

(2) The loss of carbon due to the production (or loss) of carbon-monoxide.

(3) The variation of the products of combustion due to variations in the demands made upon the engine, *e.g.*, weight of train drawn, speed, gradient.

(4) Whether chemical equilibrium conditions corresponding to the fire-box temperature are ever attained.

(5) The variation of the products of combustion with the depth of fire.

Theoretical Part.

The essential parts of a locomotive fire-box consist of a copper box, which is water-jacketed above and on both sides and closed by iron fire-bars below. The products of combustion flow from the fire-box through tubes to the smoke-box and thence to the chimney. The fire is placed upon fire-bars, and the fire-box is filled with fuel nearly to a level with the door, the top surface of the fire being, roughly, parallel with the brick arch. The air necessary for the combustion is admitted from below by means of the dampers, placed in front of and behind the ash-pan, and thence through the fire-bars (this is called primary air); and then a further quantity of air is admitted through the fire-door, which is partially opened (secondary air), in order to burn any combustible gaseous products, mixing being effected by the gases whirling round the edge of the brick arch on the way to the fire-tubes, and ultimately to the smoke-box and funnel. The draught is caused by the escape of the exhaust steam up the funnel, thereby producing a partial vacuum in the smoke-box. When coal, containing carbon and hydrogen as combustible constituents, and wetted with water, is employed, the reactions taking place in the fire-box are :—

(1) The drying of the coal and the production of volatile distillation products of the coal which are burnt by the supply of secondary air, or lost as smoke.

(2) The combustion of the carbon of the coal by the primary air, producing carbon-dioxide and carbon-monoxide; the proportion of each present depends upon the temperature, upon the quantity of oxygen, and upon the velocity of the draught. The carbon-monoxide may be due to a primary action of the oxygen on carbon, or to a reaction of carbon-dioxide with the strongly-heated carbon, carbon-dioxide being the first product.

(3) When moist air is employed the water vapour present is decomposed by the strongly-heated carbon, that is, the carbon is burnt by the water vapour, thus—

$$C + H_2O = CO + H_2$$
$$CO + H_2O = CO_2 + H_2$$

* Abstract of a paper by Dr. F. J. Brislee read before the Institution of Mechanical Engineers.

In order to render the combustion complete, these combustible products must be burned by the supply of secondary air. By limiting the supply of secondary air, and when the fire is thick and dense, and consequently the passage of the primary air through the fire is slow, the fire-box can act as a gas-producer, the carbon being chiefly burnt to carbon-monoxide.

Now from the two thermo-chemical equations—

$$[C] + (O_2) = (CO_2) + 97{,}000 \text{ Cal. } (384{,}896 \text{ B.Th.U.})$$
$$(CO) + (\tfrac{1}{2}O_2) = (CO_2) + 68{,}000 \text{ Cal. } (269{,}824 \text{ B.Th.U.})$$

the heat of the reaction—

$$[C] + (\tfrac{1}{2}O_2) = (CO) + 29{,}000 \text{ Cal } (115{,}072 \text{ B.Th.U.})$$

is found, and hence 1 gram-molecule of carbon burning to carbon-monoxide yields only 0·29 of the heat evolved when completely burned to carbon-dioxide. Investigations of the equilibria in a gas-generator have shown that the ratio of carbon-monoxide to carbon-dioxide in equilibrium with solid carbon is constant for each temperature, and the higher the temperature the greater is the amount of carbon-monoxide. At a temperature of about 900° C. (1,652° F.) the carbon-monoxide in equilibrium with solid carbon has reached a maximum. When carbon is burned with a rapid current of air, it burns to carbon-dioxide, even at a white heat, while the equilibrium composition above 800° C. (1,472° F.), and below 1,000° C. (1,832° F.), shows that practically only carbon-monoxide is present. The products of combustion, therefore, depend upon the velocity of the air-supply, and this dependence is utilised in certain forms of gas-producers, such as the Dellwik-Fleischer.

One can assume that the first product of the combustion of carbon is carbon-monoxide in practically the maximum amount possible, corresponding to the equilibrium conditions at the particular temperature, and that this carbon-monoxide is then burnt to carbon-dioxide by the excess of air admitted, or it may be assumed that, as in all autoxidation processes, the product of the combustion of a substance is that which contains one molecule of oxygen, the primary reaction is the formation of carbon-dioxide, and the attainment of equilibrium, namely :—

$$C + CO \rightleftarrows 2\,CO$$

is a secondary reaction. The secondary reaction will or will not take place according as the carbon and the carbon-dioxide are in contact for a sufficient time for the reaction to be completed. The velocity constant is at present unknown, but Boudouard* has shown that when air is led over carbon heated to 800° C. (1,472° F.) the quantity of carbon-monoxide decreases with increasing velocity of the air-current. This points to the conclusion that the carbon-dioxide and carbon were in contact for an insufficient length of time for the secondary reaction, forming carbon-monoxide, to take place. In the combustion of coal in the fire-box, the quantity of carbon-monoxide and carbon-dioxide in the gaseous products of combustion will depend upon (1) the temperature, (2) the velocity of the draught, (3) the depth of the fire, (4) the pressure. For the sake of simplicity the combustion of coal in the locomotive fire-box will be considered as the combustion of carbon, since upon the introduction of fresh coal into the fire there results a coking of the coal, the volatile products being distilled off and burnt by the supply of secondary air or lost as smoke. The coked coal then sinks down in the fire-box, forming a thick and fairly dense layer, through which the air is drawn by the escape of the exhaust steam up the chimney. The equilibrium, which is of great importance for consideration at present, is that denoted by the equation,

$$C + CO_2 \rightleftarrows 2\,CO \quad \ldots \quad \ldots \quad \ldots \quad (1)$$

The equilibrium

$$CO_2 \rightleftarrows CO + \tfrac{1}{2}\,O_2 \quad \ldots \quad \ldots \quad \ldots \quad (2)$$

need not be considered, as the proportion of carbon-dioxide dissociated is small at the temperature of the fire-box. The ratio C_{co}/C_{co_2}† is of great importance in the present instance

*Comptes Rendus, 1900, 130, 132; Bull. Soc. Chim., 1899, 21, 712.

†C_{co} denotes percentage of CO by volume, and C_{co_2} percentage of CO_2 by volume in the gaseous products of combustion.

as it gives the ratio of the weight of the partially burnt carbon to that completely burnt. The ratio $C_{co}+C_{co_2}/C_{co}$ is also extremely important, as it is a measure of the carbon partially burnt compared to the total amount consumed. The ratio C_{co}/C_{co_2} can vary between the limits of zero and infinity; and the ratio $C_{co}/C_{co}+C_{co_2}$ between the limits of zero and unity. For efficient combustion these two ratios should be as small as possible, the maximum of efficient combustion being reached when they are both zero. When the combustion takes place in atmospheric air (21% oxygen and 79% nitrogen by volume) the proportion of carbon-monoxide can vary between the limits of 0 and 34·71%, while the carbon-dioxide can vary between 0 and 21%. When coal, containing carbon and hydrogen as combustible constituents, is employed, the percentage of carbon-dioxide is usually between 9 and 14%.

Strache† explained the combustion changes in a gas-producer in a manner which can be applied, with a little modification, to the locomotive fire-box combustion processes. The fire can be considered to be made up of a number of parallel layers. Each layer consists of pieces of coal, or coke in the lower layers, and between the pieces air spaces which vary with the size of the pieces used. With pieces about the size of a man's fist these spaces constitute one-fiftn to one-fourth of the total cross section. Each piece of fuel is surrounded by a layer of air a few millimetres thick in some cases and several centimetres thick in others. The amount of air drawn through the fire depends upon the size of these spaces. At the point of contact between the fuel and air the combustion takes place, and here the combustion temperature must be reached, which, according to Le Chatelier, is about 1,200° C. (2,192° F.) for cold coke, if burnt to carbon-monoxide, or 2,040° (3,704° F.) if burnt to carbon-dioxide. For previously warmed coke the combustion temperature is about 1,700° C. (3,092° F.). At the surface of contact between the coke and air all the conditions are fulfilled for the formation of carbon-dioxide, viz., carbon at a high temperature and air at a high velocity. If it is assumed that carbon-monoxide is the first product of the combustion of carbon with air, then this is burnt by the air in the spaces between the fuel, and hence the product of combustion in the lowest layer is carbon-dioxide (this has been found to be the case in gas-generators). The spaces between the fuel contain large quantities of air which do not come into contact with the surfaces of the fuel, since the velocity of flow of the air in these spaces is 4 to 5 times as great as that calculated for the whole of the fire-box, and there is no time for the air to get into contact with the carbon. This air serves to burn the next layer of fuel producing carbon-dioxide (again, in the case of a gas-generator, the existence of carbon-monoxide and dioxide and oxygen together has been proved). As the gases make their way through the fire they are mixed together by striking against the fuel, so that no carbon-monoxide can exist in the presence of free oxygen in the gases as they reach the higher layers of the fuel. If the temperature of the upper layers is high, then reduction of the carbon-dioxide coming up from below takes place. When the combustion products reach the top surface of the fuel they are met by the supply of secondary air entering the partially opened fire-door, and complete combustion of the gases depends upon (1) the thorough mixing of the gases and air, and (2) the velocity with which the gases are swept into the fire-tubes and cooled to a temperature at which the rate of combustion is slight. Boudouard *(loc. cit.)* has shown that when air is led over carbon heated to 800° C. (1,472° F.) at different velocities, carbon-monoxide and oxygen are found existing together in the products of combustion. The following table gives Boudouard's results:—

Volume per cent.

Velocities per min. Volume in Litres.	Cub. ins.	Carbon dioxide.	Carbon monoxide.	Oxygen.	Nitrogen by dfrnce.
0·10	6·10	18·2	5·2	0·00	76·6
0·27	16·48	18·43	3·8	0·47	77·30
1·30	79·33	18·92	1·88	0·97	78·23
1·465	89·40	19·9	1·83	—	78·27
3 2	195·28	19·4	0·93	0·93	78·74

† Journal Gasbeleucht, 1903.

The equilibrium mixture corresponding to this temperature, 800° C. (1,472° F.) is:—

Carbon-dioxide	0·92 %
Carbon-monoxide	34·32 %
Nitrogen	64·76 %

from these results it is evident that when the velocity of the air is high, equilibrium is not attained, and the quantity of carbon-dioxide and carbon-monoxide in the products of combustion depends upon the velocity of the air. In the locomotive fire-box it is extremely improbable that equilibrium corresponding to the temperature, which is estimated at 1,000° C. (1,832° F.) to 1,200° C. (2,192° F.), is ever attained, since the products of combustion and the carbon are in contact too short a time for equilibrium to be reached, but owing to the intermittent character of the steam-blast which causes the flow of the air to the fire, some reduction of the carbon-dioxide to carbon-monoxide will take place. A large number of samples of the products of combustion, taken from the smoke-box, have been analysed. The samples were taken under different conditions, *e.g.*, weight of train, speed and gradient. The method of sampling the gaseous products of combustion will now be described.

EXPERIMENTAL PART.

The products of combustion of the fuel in the locomotive

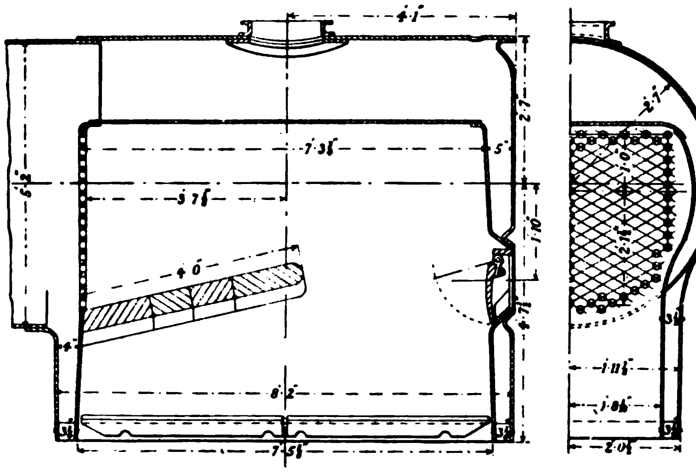


Fig. 1.

fire-box were collected in the following way: two L. and N.W.R. locomotives were employed.

The first experiments were made upon a locomotive of the "Precursor" class, first introduced in 1904, and the second series upon one of the "Experiment" class, which came out in 1905. Figs. 1 and 2 show sections of the fire-boxes of these two classes of locomotives, of which the leading particulars are:—

	Precursor class.	Experiment class.
Engine	"Adjutant," No. 675	"City of Lichfield," No. 165
Cylinders	19 by 26	19 by 26
Heatings, surface tubes .	1848·4 sq. ft.	1908 sq. ft.
,, ,, firebox	161·3 sq. ft.	133 sq. ft.
,, ,, total ...	2009·7 sq. ft.	2041 sq. ft.
Tubes 1 in. diam. inside.	301	291
,, length between plates	12 ft. 2¼ in.	13 ft. 6 in.
Grate area	22·4 sq. ft.	25 sq. ft.
Boiler pressure	175 lbs. per sq. in.	185 lbs. per sq. in.
Wheels, radius truck ...	3 ft 9 in.	3 ft. 9 in.
,, coupled ...	6 ft. 9 in.	6 ft. 3 in.
Total weight, full ...	96 tons 15 cwt.	102 tons 15 cwt.

The gases were drawn out of the smoke-box on the right-hand side by means of a wrought-iron pipe 1 in. diam., which reached to about the centre of the smoke-box. The position of this pipe is shown in fig. 3.

The tube was well clear of the exhaust steam and the steam-blower. The inside end of the tube was closed, and a saw-cut ⅛in. wide was made in the iron tube on the side

facing the fire-tubes. Outside the smoke-box the 1in. pipe was connected with a ½in. wrought-iron pipe, which was carried along the handrail on the right-hand side of the engine to the cab, where it terminated in a well-fitting tap, which served to close the tube when not in use. All joints were made air-tight by means of red lead. The gases were collected in glass tubes, having a capacity of about 100 cm.^{3} (6·1025 cubic inches), and fitted at each end with a well-ground glass tap. At first it was attempted to use a mercury aspirator to draw the gases from the smoke-box to the sample tubes, the aspirator being fitted with a wooden case attached to the side of the cab; but although it served to aspirate the gases, the drawbacks of a mercury aspirator became only too apparent for satisfactory working, especially when the engine was travelling at high speeds. After a single run it was replaced by one of Fletcher's collapsible bellows aspirators, by means of which large quantities of the products of combustion could be drawn from the smoke-box and collected in a very short time. This form of aspirator was found to be efficient and satisfactory in every way.

The samples of the products of combustion were obtained thus: the end of the tap on the cab was fitted with a "dust filter," consisting of a glass tube containing a plug of fine asbestos fibre between two plugs of glass wool. This served to remove the dust from the gases drawn out of the smoke-box. The dust filter was then connected with the sample tube and the sample tube to the aspirator by means of stout rubber tubing. Ten strokes of the aspirator bellows sufficed to draw about 1 cubic foot of the products of combustion from the smoke-box and through the collecting tube, and since the capacity of the apparatus between the smoke-box and cab

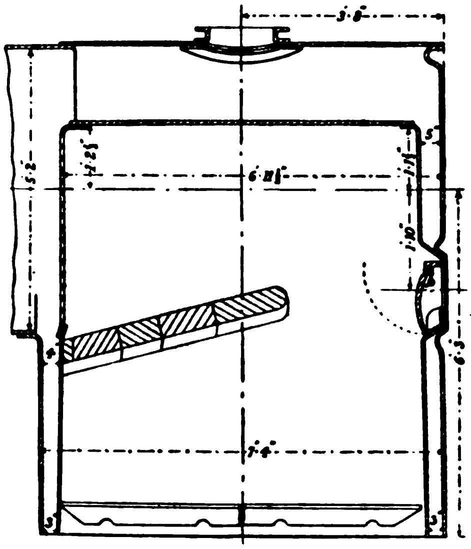


Fig. 2.

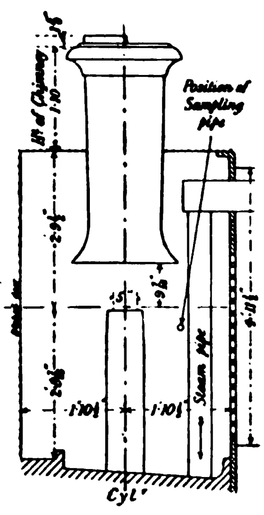


Fig. 3.

was only about 0·03 cubic foot, this was more than sufficient to remove all the gases from the dead space between smoke-box and cab, and so to ensure that the sample taken was a representative one of the products of combustion at the time of sampling. The speed and gradient were noted, and in the later work the partial vacuum in the smoke-box was measured. All the samples (with one or two exceptions) were taken with the fire-door partially closed so as to regulate the supply of secondary air. When the fire-door is open most of the air enters through it since the least resistance is offered to its passage in this direction, and comparatively little air passes through the fire. In no case was the ordinary working of the engine departed from, the stoking being left entirely to the fireman. The samples were taken during the intervals of firing, a minute or two being allowed after firing for the fire to clear. Each sample is therefore representative of the conditions prevailing in the fire-box during that particular period of working. The samples were analysed by pumping the gases out of the sample tubes with a Töpler pump, and analysing them in a gas burette, using mercury as the containing liquid and a modified form of "Huntley's" pipette for the reagents. The chief constituents of the products of combustion were carbon-dioxide, oxygen, carbon-monoxide, and nitrogen, only the merest traces of hydrogen and hydro-carbons being found in the gases. The samples represent the mean composition of the products of combustion at the time of sampling.

(To be continued.)

Natal Government Railways, 1907.

The Annual Report of the general manager, Mr. Edward R. Ross, upon the working of the Natal Government Railways during the year 1907, states that:—

The capital expenditure amounted to £302,760, which, added to that of previous years amounting to £13,692,969, made a grand total of £13,995,729. The open mileage was increased by 41½ miles.

The total revenue amounted to £1,843,148, an increase of £6,232, or ·34 per cent. The working expenditure amounted to £1,273,587, an increase of £36,976, or 2·99 per cent. This expenditure includes £15,644 upon additions and improvements to buildings, ways and works.

The working expenditure was 69·09 per cent. of the gross revenue, or an increase of 1·77 per cent.

The annual revenue during the last four years was:—

	1907.	1906.	1905.	1904.
	£	£	£	£
Passengers	418,263	424,705	457,179	453,875
Parcels	41,325	41,487	42,588	41,354
Mails	11,763	10,799	7,850	5,644
Rents and Miscellaneous	51,884	59,844	67,954	53,544
Goods, Minerals, and Live Stock	1,319,913	1,300,081	1,459,366	1,379,517
Total	1,843,148	1,836,916	2,034,937	1,933,934

The expenditure was:—

	1907.	1906.	1905.	1904.
Maintenance of Ways and Works	211,523	164,176	162,129	177,631
Locomotive Power ...	471,952	468,586	497,906	585,282
Repairs and Renewals of Carriages and Wagons	162,809	151,228	139,767	185,768
Traffic Expenses ...	341,857	359,652	380,841	384,658
General Charges ...	69,802	75,902	66,809	68,169
Works Renewals and Improvements ...	15,644	17,067	42,007	129,702
Total	1,273,587	1,236,611	1,289,459	1,531,210

The increase in the expenditure by £36,976 in comparison with the previous year is accounted for under Maintenance, Locomotive, and Carriage and Wagon Departments. The open mileage maintained showed an increase of 81 miles. In the maintenance of Ways and Works, extensive renewals in the permanent way were called for, representing on the main line a sum of not less than £44,545. An increased expenditure of £4,329 was incurred under locomotive power, but the year witnessed an increased train mileage of 226,811 miles and the movement of 194,727 additional tons of low grade traffic. As the high tractive engines were worked at great pressure during the latter half of the year, considerable expenditure on account of renewals will fall into the next year's account. The upkeep of wagon stock involved an increased expense of £12,241, attributable to the greater work done.

The original stock of steel wagons now requires heavy repairs, and for some years to come the department will be faced with a considerable expenditure, which, like the permanent way, would, under a joint stock company, have been provided for out of the surplus revenues of former years, as has in the past been unsuccessfully advocated by the management.

The main features in the working of the year were.—(*a*) the continued heavy loss in seaborne Overberg traffic, both in tonnage and revenue, amounting in the latter case to as much as £139,309 as compared with 1906, and £299,384 as compared with 1905; (*b*) the increased coal traffic which sprung up towards the middle of the year, and (*c*) the commencement of a large export traffic in maize.

The continued heavy loss in Overberg trade, uncompensated as it was by any favourable development elsewhere, caused the management much anxiety during the earlier months of the year, during which the administration was actually working at a loss. Towards the end of the year a very satisfactory development in the coal traffic enabled leeway to be made up, with the result that the Department, for the year under review, was just

able to meet all working expenses, interest and sinking fund with a small surplus of £8,974.

Although, from a railway point of view, the rates charged on the maize traffic are so low as to be unremunerative, the departure marks a new era in the development of the colony which will undoubtedly, as time goes on, prove of the utmost value, both to the railway and to the country as a whole.

While a certain percentage of the Overberg trade to the Rand will no doubt always be retained, it is at present a diminishing factor, and it should be recognised that, at any rate for the next few years, the main traffic on the line will probably consist chiefly of coal, maize, wattle, and other agricultural products for export, which, from their very nature, cannot stand a high rate of carriage. The expense of working such traffic on a line such, with its severe gradients and curves, and with the high wage rate prevalent in the Colony, is necessarily great, while the receipts are small. It would, therefore, not be wise to anticipate that the railways will be able to do more than cover the cost of working and interest on capital expenditure for some time to come.

In dealing with the heavy coal traffic that may reasonably be anticipated will continue to develop, a clear line of policy is recommended as follows:—(*a*) the steady improvement of adverse gradients and curves; (*b*) the maintenance of the permanent way at its highest standard; (*c*) the improvement of the engine power by the regular annual augmentation of the existing engine stock with up-to-date and heavy locomotives; and (*d*) the improvement of the rolling stock by a steady further supply of high capacity wagons.

True economy lies in the maintenance of the highest standards in every section, and although doing this will involve heavy and continuous outlay, it is only by this means that the utmost efficiency can be secured and working costs reduced to the lowest possible figure.

The following figures show the extent to which the Coal Traffic has increased:—

	1907.	1906.	1905.
	Tons of 2,000 lbs.		
For Bunker and Export Oversea	1,168,532	846,517	716,809
To Stations in Natal and other Colonies	248,220	257,442	279,508
For Railway and Harbour Departments	268,408	279,478	265,876
Total	1,685,160	1,383,437	1,262,193

The average daily tonnage loaded at the mines during the last half of the year amounted to 6,122 tons, while the maximum reached 7,754, and has been worked down to the port, on the average, within three days.

The total mileage operated by the Natal Government railways at the end of the year was 1,064¾ miles, of which 88¼ were worked on behalf of the Central South African Railway Administration under agreement.

Hollow Reinforced Concrete Poles and Pipes.

In our last issue we referred briefly to the new process of manufacturing hollow poles and pipes of reinforced concrete just been introduced into this country by Messrs. Siegwart, Ltd., of 1, Great Chapel Street, Westminster. It is the invention of Mr. Hans Siegwart, of Lucerne, Switzerland, who is well known as the inventor of a system of reinforced concrete fire-resisting floor construction made up of hollow tubular beams laid side by side. Mr. Siegwart is noted for his originality of outlook in dealing with concrete, for in making his beams he builds them in slab form and cuts them up into separate beams by means of a saw while the concrete is still soft, *i.e.*, just as it has begun to set. In his latest invention he has treated the material in a strikingly original manner. The principle that he has worked upon is entirely different to the customary method of manufacturing concrete, namely, by casting it in a mould and allowing it to harden therein. Mr. Siegwart uses the material in a plastic way very much like clay, for by his process of wrapping the concrete round a core no moulds are required to give it shape and form.

Poles and pipes are made by a machine which has been installed at Messrs. W. Cubitt and Co.'s works, Gray's Inn Road, London, W.C.

With regard to reinforced concrete poles (which show the capabilities of the Siegwart machine to the best advantage, though perhaps the manufacture of pipes is of greater importance), their construction has been attempted for some years. Electricity is used for so many and such multifarious purposes at present, and its use has been extending so rapidly of recent years, that means of conveying electricity from point to point have obtained great importance. Overhead transmission lines, both for power purposes and for telegraphs, and the running of tramways, is the favourite method. The supports for these overhead lines are costly, and also must provide every security. At first timber poles were adopted, and they are extensively used to-day, their first cost being much less than iron poles, though their life is comparatively short. By various means, such as creosoting, a life of about six years is increased to about ten years. A steel or iron pole, though expensive in first cost, proves economical, but it must be periodically painted, and the cost of upkeep is considerable.

There is no particular difficulty in casting a solid reinforced concrete pole, but when the endeavour is made to manufacture a hollow pole, difficulties immediately stand in the way. The Siegwart process, however, enables hollow reinforced concrete poles to be constructed at a price which is very much less than the first cost of iron poles.

Where poles are required for long-distance transmission, the importance of adequate security is very great, for the execution of repairs and painting over a wide area is troublesome and costly. For such purposes the reinforced concrete pole offers advantages which place it far ahead of any other. The Siegwart poles have been constructed on a proper theoretical basis of calculation with any desired factor of safety, and tests have been conducted upon poles of standard construction which have established a safety factor of 5.5. Furthermore, large contracts have, we understand, been placed abroad by municipalities with the licensees for the Siegwart patent for large numbers of Siegwart poles, which, naturally, has put them to the severest test of actual practice, and has proved the efficiency and economy of these poles.

The following comparative estimates of the cost of Siegwart poles, compared with other poles over a period of 50 years, are interesting, and should arrest the immediate attention of engineers:—

Tramway Poles,	29ft. high. Siegwart. £ s. d.	Iron. £ s. d.	Wood. £ s. d.
Price of Pole	3 0 0	6 10 0	14 5
Erection	1 0 0	1 0 0	9 7
Painting or Renewal......		2 11 0	9 8 4
Total cost in 50 years......	4 0 0	10 1 0	10 12 4
Power Distribution Poles, 36ft. 6in. high.			
Price of Pole	4 0 0	9 0 0	19 3
Erection	1 4 0	2 0 0	9 7
Painting or Renewal......		2 11 6	12 5 0
Total cost in 50 years......	5 4 0	13 11 6	13 13 10

The Siegwart process of manufacture has given additional arguments in favour of reinforced concrete pipes, apart from the economy which is claimed to be effected over the other methods of manufacture. There is, for instance, a saving in the cost of joining by reason of the greater length of the pipes, these being as long as 20ft., or twice the length of iron pipes, and four times the length of plain concrete or earthenware pipes.

These pipes can be constructed to withstand very great pressures. In the case of the larger pipes, which are made up to 2ft. in diameter, the strength is, if necessary, as much as six atmospheres, while the smaller pipes are made to withstand an interior pressure of 12 atmospheres. A reinforced concrete pipe is naturally strong against external

pressure, and, if necessary, they can be specially reinforced for this purpose. It has considerable resistance against fracture during transport or by shocks caused by street traffic, being of small weight owing to the thinness of the walls, which varies from ¾in. to 2in. A Siegwart pipe is, we are informed, only about half the weight of an iron pipe of equal strength. The cost of transport is low; and, furthermore, Siegwart pipes can be manufactured at the place where required for use, so that the cost of transport, such as would be entailed in bringing either earthenware or iron pipes from a distance, is completely eliminated. A total length of 22 miles has been laid in Roumania in substitution of cast iron pipes for water works.

The Siegwart process can also be applied to the construction of hollow reinforced concrete piles, for which there is considerable demand. The pile may be filled with sand before driving.

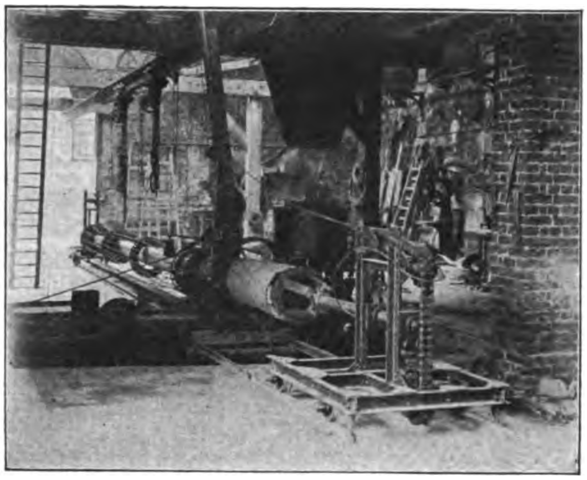


Fig. 1.

Fig. 1 shows the general arrangement of the machine for manufacturing Siegwart poles and pipes, as it has been erected at the works of Messrs. W. Cubitt and Co. The machine is in an open concrete pit, with a track on either side, upon which trestles can be run, and a stage over the machine carrying a concrete mixer which has paddle wheels which rotate in an open box that can be tipped over to discharge its contents into the hopper below over the machine; these paddles thoroughly churn up the ingredients.

The concrete used in the manufacture of poles and pipes is made of clean screened (¼in. mesh) Thames grit, proportioned 3 to 1 of Portland cement, the brand favoured being "Ferrocrete," which is a cement made by the rotary process by the Associated Portland Cement Manufacturers, Ltd. The concrete is mixed very dry, so that it only feels moist to the hand, and does not even stick together when pressed in the hand. It coheres in the manufacture by reason of the great pressure which is applied to it.

The concrete, discharged from the mixer into the hopper, falls from the latter into a sheet metal drum, seen in Fig. 2. This drum holds about 8 cub. ft., which is sufficient as a rule to make one pole or pipe. It is important in the manufacture that the concrete should be fed regularly and continuously, and this drum is arranged to do this; it slides up and down a sort of oblong box or shoot, which is so arranged that the surface of the concrete within the drum is always level with the top of this shoot. A paddle wheel with four arms rotates within the drum and scrapes the surface of the concrete into this shoot, and the drum is geared so as to rise gradually as the concrete is used up, thus always keeping the concrete level with the top of the shoot and enabling the paddle wheel to scrape the concrete regularly and continuously down the shoot. The rate at which this drum rises can be regulated so that the quantity of concrete discharged is greater or less according to the thickness of the layer of concrete which is to be applied to the core.

The core of sheet iron is removed after the concrete has been applied to it by an arrangement whereby its diameter and circumference are reduced by an internal mechanism. Gauge rings are arranged on the core at suitable distances from each other, and steel rods or wires of small section are passed through holes in these gauge rings, and arranged to lie longitudinally upon it. In the pipes these wires or rods are not stretched, for the operation of applying the concrete thereto draws them taut, but in the poles the wires are stretched tightly by means of hooks that are screwed up at the ends of the core. Upon the track two trestles are placed, as shown in fig. 1, and the core is mounted between them so as to be capable of rotation therein. The trestles have toothed pinion wheels, which engage with a rack on the track, and are drawn gradually along in the direction of the machine by means of a wire rope at the desired rate.

The concrete from the drum falls down the shoot above referred to, upon a conveyer band or belt made of strong steel wire tightly plaited that takes one wrap round the core, and is given its motion by passing over two wheels. One of these wheels (that at the front of the machine) is mounted in a sliding carriage that receives preliminary adjustment by means of a long screw turned by a spoked hand-wheel at the back of the machine. By means of the two heavily weighted levers, the sliding carriage applies a pressure of about 5,000lbs. to the conveyer-belt, so that the concrete is wrapped upon the core under this pressure. Upon the conveyer band is a band of strong webbing about 4ins. in width. The concrete falls upon this webbing, and the webbing and the concrete are wrapped round the core

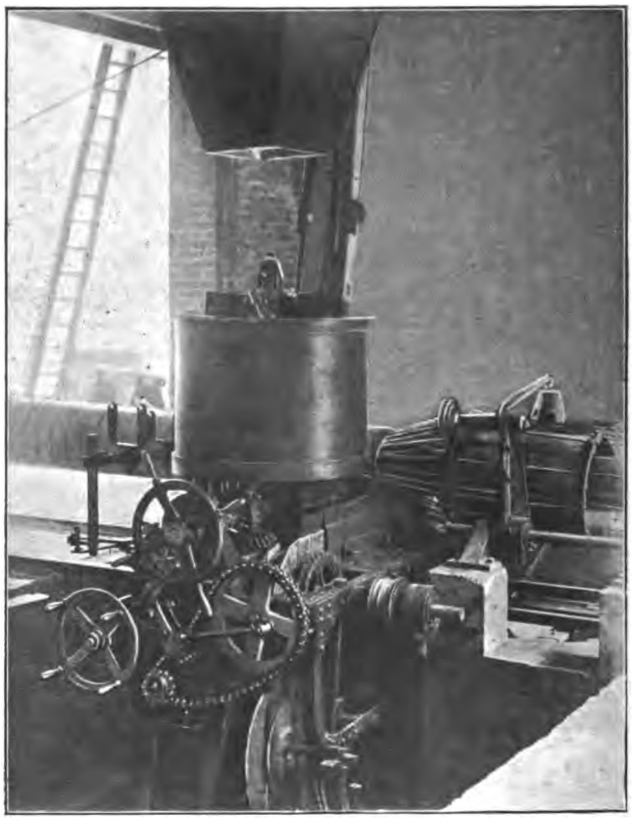


Fig. 2.

in a continuous spiral, so that the pipe or pole issues with a bandage round it, as shown in figs. 2 and 3. The edges of the webbing just overlap so that the concrete layer thereunder and the webbing are continuous, the latter so preventing the concrete dropping from the core. The pressure on the conveyer belt draws the longitudinal wire or rod reinforcements closed together. The guide rings holding the

longitudinals in position are engaged by a wheel attachment, so that they slide along the rods as the core gradually passes toward and through the machine.

Immediately the webbing and concrete issues beyond the conveyer belt, wire or wires, as close together as may be desired, are fed by a spool on the attachment somewhat resembling an elevator, to be seen in fig. 3. The webbing is drawn up over a bar above this spool of wire, so that the wires for the spiral binding may be fed upon and into

Fig 3.

the concrete. A rod fastened to this elevator attachment keeps it rigid, and the rotation of the core draws the wire or wires from the spool so hard against the layer of concrete that they penetrate into it for some distance. If these spiral wires are of large section, there is insufficient power developed to draw them into the layer of compressed concrete, therefore another device is brought into action, consisting of a wheel with spikes thereon that cut grooves in the concrete as the core rotates, into which the wires may penetrate so as to become embedded in the concrete. The rotating core draws the band of webbing upon the surface of the concrete again, and a pressure roller on the end of a long spindle, which is screwed forward by hand, works on a sheet iron ring, as shown in fig. 3, and presses this webbing and the concrete hard against the core, in order to give it a final finish and maximum hardness. The thickness of the layer is, by the great pressure given by this roller, slightly reduced, and the reduction in diameter and circumference thereby means that the quantity of webbing that was originally fed into the machine is now too long, but the slack is taken up by the elevator attachment above referred to, which is suspended by means of a wire rope running over a pulley on the platform above having a weight hung from the end thereof, this arrangement enabling the elevator to gradually rise as the amount of slack in the webbing increases.

As soon as the core has been drawn through the machine completely wrapped with the spiral binding, it is picked up by a travelling crane overhead and slung on one side to enable the concrete to harden and mature. To ensure it gaining maximum hardness it is constantly wetted.

The interior sheet metal core can be removed by being reduced in diameter by the screw attachment within after about 12 hours, and the bandage of webbing may be removed after six days' hardening. This webbing leaves a few small markings on the pole which are no detriment to a pipe or pile, nor for a pole erected in a place where appearances are not of great importance, such as in the country. To complete a pole, all that requires to be done after it comes from the machine is merely to fix a stopper in the top and make a square necking or blocking for fixing the cross-arms that carry the insulators and the electric wires. The former is cast in a mould and dropped into the top of the post; the latter is moulded by hand. Where a more finished appearance is destined, the poles are given a wash of cement grout or rendering of cement and sand, the latter giving a stone-like appearance, and, if desired, neckings or mouldings may be run round the pole and any other ornamentation done by hand; indeed, the Siegwart pole can be made very decorative, and although it is a little greater in diameter than an iron pole, this really gives it a better appearance, as the proportion is better. The pipes, as mentioned, require no external finish, but a cement grout wash may be given the interior if desired, which sometimes also receives a coat of Dr. Angus Smith's solution, or a special cement glaze. The concrete for pipes, too, can be made impermeable by the addition of a special waterproofing material. Messrs. Siegwart, Ltd., advocate the "Medusa" waterproofing material for this purpose.

Fig. 4 is a diagram of the arrangement of the reinforcement and details of the construction of a typical Siegwart pole. It will be seen that the reinforcing skeleton consists of longitudinal rods tied together by a wire or wires wound spirally thereon. It is important in such tubular construction to have the reinforcements correctly disposed, and the Siegwart process ensures every control over their position and accurate placing, whereas in the ordinary process of moulding concrete in tubular form, grave defects in this respect are of common occurrence, it being extremely difficult to ensure regularity in the disposition of the reinforcements. The process has the ordinary advantages attached to it of additional reliability given by factory labour, specialisation, and organisation.

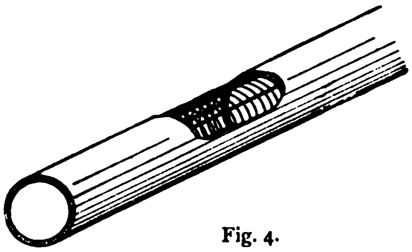


Fig. 4.

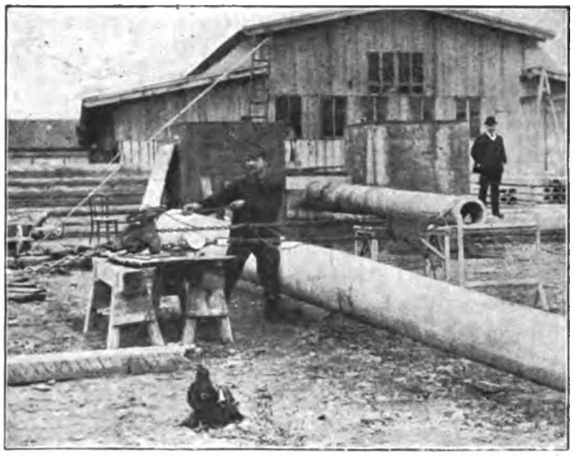


Fig. 5.

The thickness of the concrete varies from 1 to 2in. for poles, but the pipes vary from ¾in. to 2in. in thickness. A Siegwart pipe that has been tested, successfully resisted an internal hydraulic pressure of 285lbs. per sq. in. The pipes have a special shaped joint for resisting pressure. Bitumen is filled in in the hollow spaces of the joint, and a short piece of pipe is passed over the joint and con-

nected to the pipe with bitumen. It was such a joint that withstood the pressure of 285lbs. per sq. in. For ordinary pipes not called upon to sustain pressure the jointing is by means of collars of reinforced concrete or sockets on the pipes.

As regards the calculations for the size of reinforcements, thickness of shell and general proportions of the poles, the theory which is adopted is similar to that employed for the strength of chimneys, and the stresses that have to be sustained are tension on the one side and compression on the other. In chimney designing, however, it is customary to ignore the compressive resistance afforded by the reinforcement, but with a thin shell, such as is possessed by the Siegwart pole, this has to be taken into account. The problem may also be treated from the point of view of a hollow tubular beam, or rather a cantilever. The stresses that come upon the pole are not only the tension of the electric wires, but the wind pressure also. The longitudinal reinforcements in the Siegwart pole are made each in one length continuous from top to bottom as there is tension induced in them, but in the pipe construction referred to below, several rods, shorter than the total length of pipe, are often used.

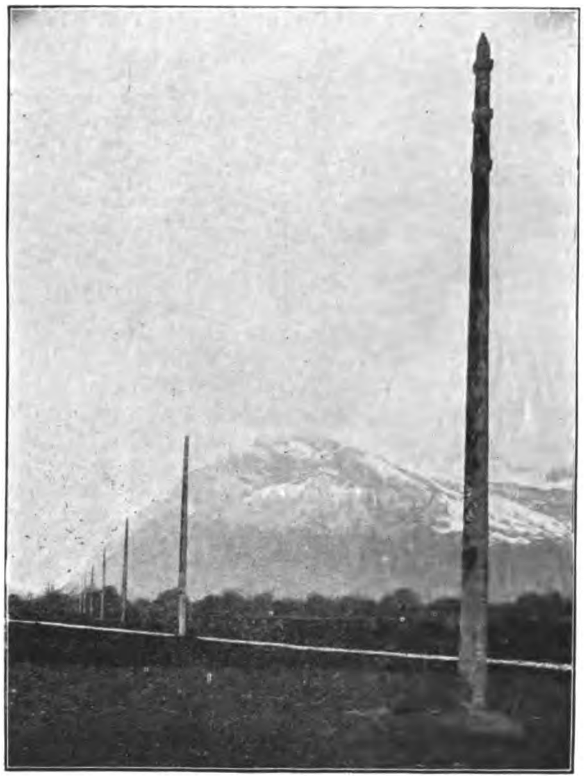


Fig. 6.

Fig. 5 shows the manner of conducting a test upon a Siegwart pole. The end of the pole was fixed rigidly between two blocks of concrete, and the top pulled on one side by means of a chain and pulley block, the tension being read upon a gauge, clearly shown in the view. The deflection of the head of the pole was read on a scale placed upon the trestle stationed in front, also shown in the view. This particular pole, which was 31ft. 2in. long, with a tensile strength of 15,400 lbs., gave a deflection of only 2·756 in. When the load was relieved the top end of the pole returned to its initial position, no permanent deflection being noticeable.

The size and disposition of the reinforcements in pipes is determined by a theory of calculations that has been thoroughly worked out. The bursting pressure from the inside is required to be resisted solely by the hoop tension of the spiral reinforcements, while the longitudinal wires resist the bending moment induced in the concrete shell between each spiral, while at the same time serving to strengthen the pipe as a beam to resist the forces to which it is subjected in transport and lifting and placing in the trenches and in lying on an irregular bed. If the pipes have to withstand pressure from without, the calculations are based on the assumption that each section of a pipe is an eccentrically loaded pillar or post. The thickness of the concrete bears a direct relation to the pressure in this latter case, but with pipes to withstand internal pressure the thickness of the shell is determined not so much by its strength as by its permeabilitiy. The thickness therefore of the concrete layer is standardised for various sizes of pipes and pressures solely from practical consideration as regards the impermeability of the concrete, shocks in transport, putting in place, etc. The predetermined thickness of the concrete shell enters into the calculation for the sizes of the longitudinal reinforcements, though it does not affect the determination of the size and disposition of the spiral reinforcements.

Fig. 7.

Hollow piles constructed by a similar process can be made up to the standard length of 39ft., which is adopted for the longest poles, though a greater length could be made if desired. The piles usually have their sides parallel, *i.e.*, they are of the same diameter throughout, but sometimes they are tapered. The system of reinforcing a pile with spiral wires is now generally looked upon as the most efficient form of reinforcement.

Columns for ordinary building work can be made advantageously by the Siegwart process.

Fig. 6 shows a line of Siegwart poles that has been erected in the country where no special finish is required. This view, therefore, shows the poles just as they come from the machine with the markings upon them left by the webbing.

Fig. 7 shows a more decorative pole which has been finished with a smooth surface. This is erected at Miggern, Switzerland, and has a total height of 54ft. above the ground. As this height is greater than the standard length of poles manufactured it has been obtained by fixing an ordinary pole in a base which stands 16ft. 5ins. above the ground, and embedded 6ft. 6ins. in the ground, resting upon a foundation of rough stones and filled with stones to

form a bearing for the pole proper. The pole in this case is quite plain.

Fig. 8 shows the manner in which this pole was erected. This shows how it was simply slung from the middle. It is interesting to note that a pole, having hardened only for four days after manufacture, was lifted and put into a vertical position at the works in Gray's Inn Road, and withstood this severe test without showing any ill-effects.

Eight men have been employed to work the machine in the experimental stages, but eventually only 7 men will be

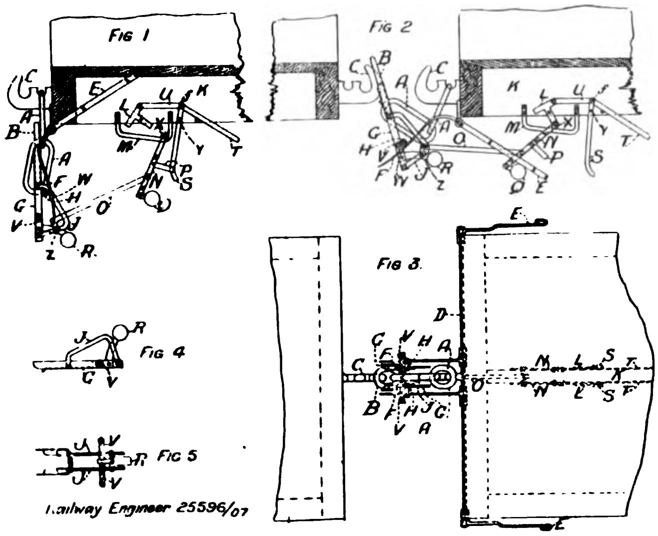
Fig. 8.

required. One labourer is engaged feeding the mixer for the concrete; two labourers and a foreman are engaged working the machine; two lads are engaged in placing the reinforcements on the core, and one man is required to remove the poles. Only one skilled man is thus required. The capacity of the machine is, roughly, about one pole an hour, though with smaller poles and pipes the time required is slightly less. The concrete, of course, is not a big item, and the metal is also of small amount, and costs very little. It will be seen, therefore, that the cost of constructing a Siegwart pole or pipe is small, and the prices at which they can be produced are very low. The market for poles, pipes and piles is an extensive one, and there should be a great future for the invention in this country. These poles appear to be particularly suited for carrying signals of all kinds, as all maintenance charges would be saved.

Recent Patents Relating to Railways.

These abridgments of recently published specifications are specially compiled for this review by Messrs. Wheatley and Mackenzie, Chartered Patent Agents, 40, Chancery Lane, W.C., from whom copies of specifications can be obtained at an uniform price of 8*d.* each.

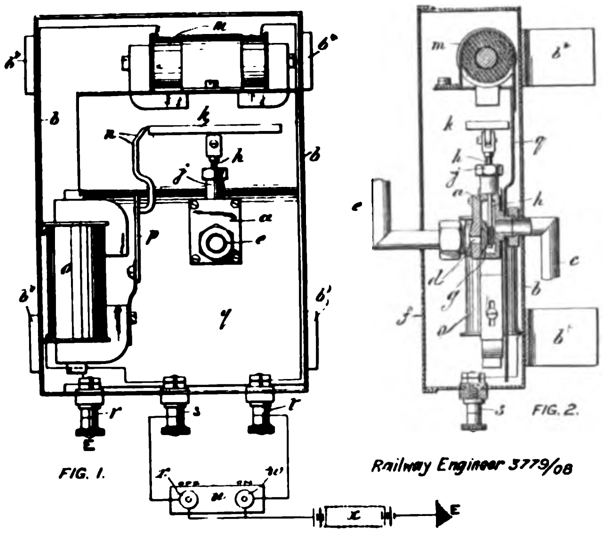
Couplings. *25,596. 19th November, 1907. A. Wren Ferndale, Chandlers Ford, Eastleigh, Southampton.* A carrier G arranged to engage the end link of the usual coupling chain is suspended by arms F from a cross-shaft D, provided with operating handles E. Behind the coupling, pivoted tee-pieces L and bars M are arranged on opposite sides of a bearer K, also rollers XX, which roll on the bars M, and are mounted in links N connected with the carrier G at Z by a link O. The links N each carry two balance weights P Q, and the carrier G a balance weight R, the latter serving to retain the apparatus in the disengaged position. Arms S S are pivoted at Y and connected with the tee-pieces L by links U. Arms T T, which serve as balance weights and which join into the arms S at the point *f* are provided, and stops beneath the arms T T limit their downward movement. Rollers V V are fitted on the carrier G and a swell W is formed on the curved arms FF. To couple two vehicles together, the handle E is sharply jerked upwards, partially rotating the rod D, which serves to bring, by means of the various connecting parts, the tee-pieces L L, into the position shown in Fig. 1, that is to say into such a position that the rollers X X can pass beneath the tee-pieces. Upon then pressing down the crank handle E while the tee-pieces are still in the position shown by Fig. 1, the curved arms F F are hinged away from the end of the vehicle, lifting up with them the carrier G, due to the arrangement of the rollers H H on the arms F F with the parts J J of the carrier. The rollers V V and H H might, of course, be replaced by pins or the like. The carrier is thus elevated, carrying with it the end link B, which is housed in the carrier. As the handle E is further depressed the ends of arms F, and finally the swells W W on the arms F F, engage with the rollers V V on the carrier, as shown in Fig. 2, and the rollers X X carrying the links N N on the bars M M are drawn lengthways along these bars beneath the raised ends of the tee-pieces till they are arrested by the upturned portions at the ends of the bars M M, and as the carrier is connected to the rollers X X by means of



the link O and links N N, further sharp downward movement of the handle E results in the elevation and tipping forward of the carrier G into position with the end link B, over the drawhook, when, upon suddenly releasing the handle E, the end link B, continuing its forward movement by its momentum and being no longer supported by the arms, falls forwards and downwards and is deposited on the drawhook C of the opposite vehicle. The carrier G with its attached gear then returns into the position shown in Fig. 1, being assisted by the action of the balance weights P, Q, and R. In coupling the vehicles the rollers X X strike against the left hand top arm of the tee-pieces and tend to return them to the position shown by Fig. 2, assisted by the balance arms T. As the carrier falls back after coupling, the rollers X X pass back along the bars M and beneath the tails of the tee-pieces. To uncouple the vehicles the curved arms F F are hinged upwards by depressing the handle or handles E, and as the tee-pieces L L have moved into the position shown in Fig. 2, that is to say with their tail pieces in the path of the rollers X X, the latter are arrested by the tails of the tee-pieces. The arms F then lift the carrier which engages with the end link B and lifts same off the drawhooks C of the opposite vehicle. (*Accepted 9th April*, 1908.

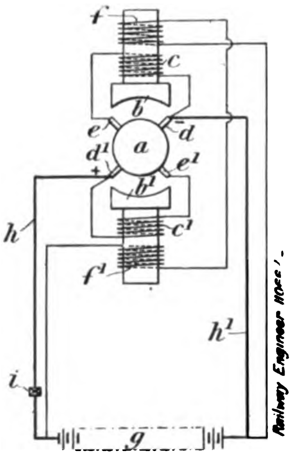
Gas Lighting Apparatus for Trains. *3,779. 19th February, 1908. A. Spencer, 77, Cannon Street, London.* The passage of gas to each burner or group of burners is controlled by a slide *g* that is maintained on its seat by the pressure of the gas in the gas supply main, so that the use of packing is avoided. Gas from a main supply pipe is led to the valve chest *a* through an elbow branch *c* that passes through the back of the box *b* and from the valve chest such gas is led to the pipe that feeds the gas burners through a port *d* in the valve chest cover and an elbow branch *e* that passes through the front of lid *f* of the box. In some cases each valve *g* is directly connected to the

armature *k* of an electro-magnet *m*, which is arranged to move in the path of a catch *n* that is controlled by a second electro-magnet *o*, the arrangement being such that, when the first electro-magnet is energised to move the valve in one direction it is retained by the catch in that position until the second electro-magnet is energised, when the catch will be moved to release the valve and allow it to close, it may be under the influence of gravity or a spring or both. In other cases the



slide valves are each actuated by an electrically operated motor of the kind described in the Specification of prior Letters Patent No. 13815 of 1907 comprising a rotary armature, the spindle of which is connected to the valve through mechanism comprising a pin and slot or other lost motion device whereby the momentum of the rotary armature and attached parts is utilised to rapidly actuate the valve. (*Accepted 30th April, 1908.*)

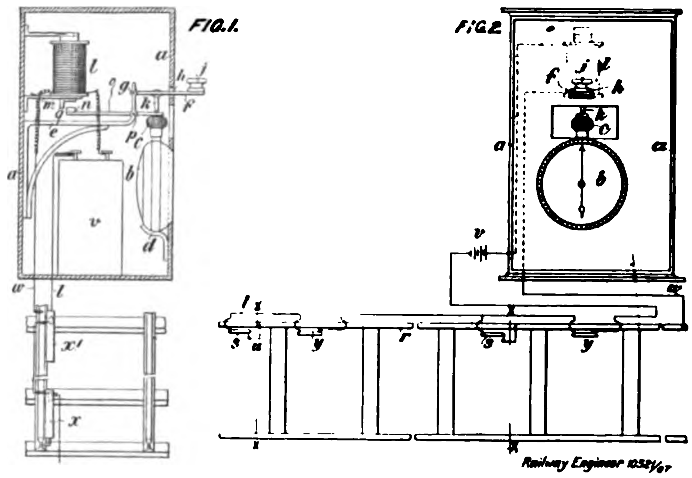
Dynamos for Train Lighting. *11,066. 11th May, 1907. H. Leitner, Maybury, Woking.*



This invention provides for the more rapid building up of the voltage of dynamos of the type referred to in a prior patent No. 9655[05]. To this end magnet *c* c^1 is excited from a separate source of current *g* flowing through separate windings *f* f^1. With this arrangement when the dynamo is started its field is strengthened by the current flowing from the battery *g* through the windings *f* f^1, whereby the voltage of the machine is rapidly built up. When the voltage of the dynamo has reached a predetermined point the switch *i* connects up the battery *g* to the main brushes. By properly proportioning the windings *f* f^1 the output curve of the machine can be modified as desired. (*Accepted 7th May, 1908.*)

Indicating or Recording Apparatus. *10,321. 3rd May, 1907. W. R. Preston, of J. Stone and Co., Ltd., Deptford, Kent.*

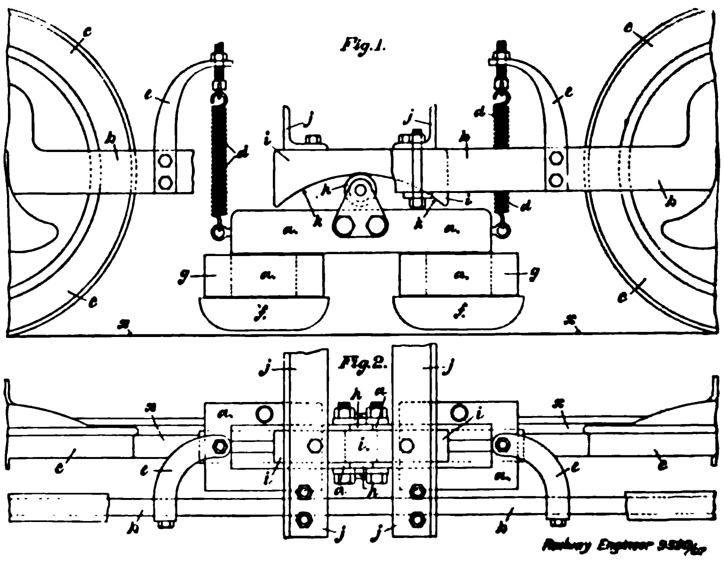
This invention relates to apparatus for indicating or recording the time occupied by a locomotive, train or other railway vehicle in passing over a measured length of road, and from which the speed may be computed. The object is to provide a simple apparatus which, up to a certain point, is automatically operated by the passing of an engine or other vehicle over the section, and thereafter merely requires a single operation by the observer to be in a condition for recording or indicating the speed of the next train passing over the section, or the time occupied by such vehicle in traversing the measured length of track, as the case may be. The apparatus consists of a suitable stop watch or speed indicator (*b*), supported in a convenient frame or casing, a hand lever (*f*) for setting the watch or indicator to zero, an electro-magnet (*l*), the armature of which is arranged to operate an appropriate device (*n*) for starting the watch or indicator and for subsequently stopping it, a battery, having one pole connected to one terminal of the magnet windings, the other terminal being conveniently earthed, and having the other pole connected to a line wire running along the track and including earthing switches and circuit breakers at the two ends of the measured section, such switches and circuit breakers being fitted with abutments, tumblers or the like to be engaged by the wheels of, or suitable projections on, the locomotive or other vehicles. A locomotive or train passing over the treadle (*x*) displaces the treadle and closes the switch (*s*), which, as seen in Figure 2, is normally open, thus completing the circuit comprising the battery (*v*), line wire (*t*), switch (*s*), wire (*u*), earth wire (*w*), coil (*l*), and energizing the magnet, which thereupon attracts its armature (*n*), and depresses the head or knob (*c*) of the stop watch (*b*), the hands of the latter thereupon commencing their movement. Immediately afterwards the locomotive displaces the treadle (x^1), situated say only five yards ahead, and the circuit breaker (*y*) is operated to break the circuit and to thus de-energize the magnet, so that the knob (*c*) is free to resume its original position under the action of the spring within the watch. The locomotive having passed over the measured section now displaces a third treadle similar to *x* and closes the second switch (*s*) at the end of such section and the magnet again attracts its armature (*n*) and depresses the knob (*c*)



thereby stopping the hands of the watch (*b*). After this the second circuit breaker (*y*) is operated, the magnet de-energized and the armature released, permitting the knob (*c*) to rise again, so that all that remains to be done, after taking of the reading by the signalman or other observer, is the depression by hand of the lever which re-sets the watch (*b*) or other indicator to zero. (*Accepted 4th May, 1908.*)

Electric Brakes. *9,390. 23rd April, 1907. J. F. Simpson, 35, Lower Bank Road, Fulwood, Preston.*

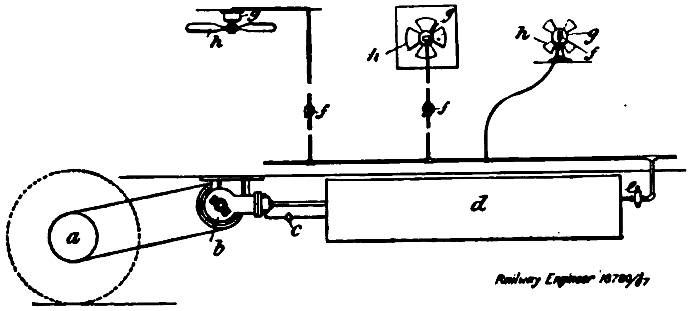
Brakes for electrically propelled vehicles or locomotives are, according to this invention, so connected with the frame of the vehicle that when the brake blocks are brought magnetically into



contact with the rails they are caused to move relatively to the frame, whereby the weight of the vehicle is transmitted directly to them. The mechanism by which the weight of the vehicle can be exercised to exert vertical pressure downward through the brake shoes *f*, and their carriers, comprises a roller *h* on the upper part of the magnets *a*, and a device *i* carried from the cross bars *j* of the truck or vehicle frame; this device *i* having a double curved inclined underface *k*, in connection with which the roller *h* works. When the car moves forward, and the brake shoes *f* are electrically brought on to the rails, the resistance to the forward motion produced thereby causes one of the inclines *k* to act upon the roller *h*, and so press the brake mechanism, that is, the magnets *a* and shoes *f*, down on to the track. (*Accepted 23rd April*, 1908.)

Carriage Ventilating Apparatus. *18,780. 20th August, 1907. J. E. Howard and C. E. Crighton, Fort Road, Eastbourne.*

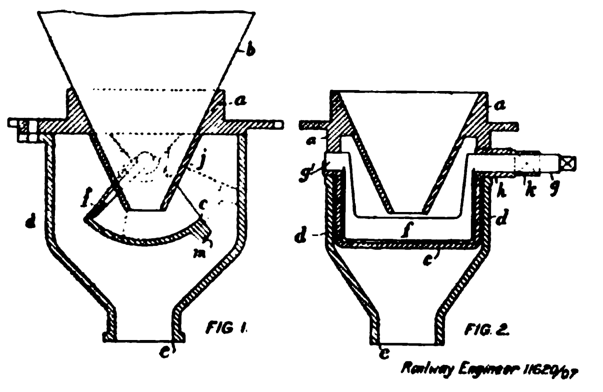
According to this invention an air compressor *b* is driven from the axle *a* and the compressed air is stored in a receiver *d* and is used to drive a fan or fans *h*. The receiver is of sufficient capacity to keep the fans in operation while the train is stationary.



The air is preferably passed through a reducing valve *e* and thence through a small valve which can be controlled by the passengers for starting and stopping the fan to a small pneumatic motor running in an oil bath. When it is desired to ventilate a dining car or smoking compartment an exhausting fan may be used. (*Accepted 21st May*, 1908.)

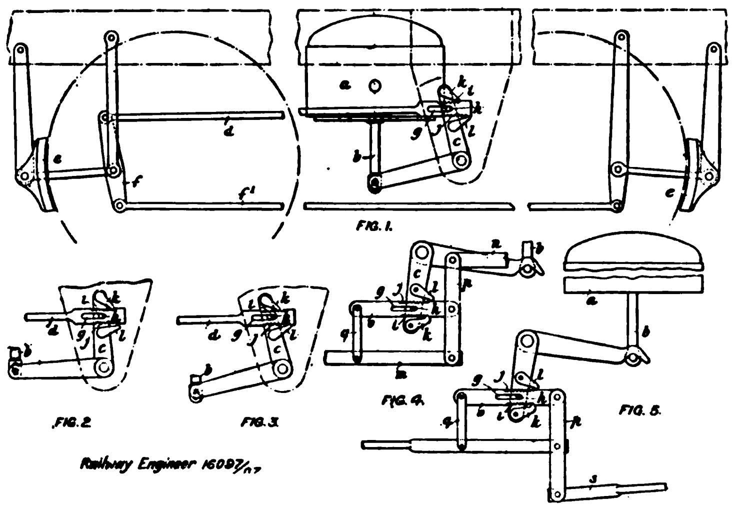
Sand Boxes. *11,620. 17th May, 1907. J. E. Anger, United Electric Car Co., Ltd., Strand Road, Preston, Lancaster.*

A plate or shelf is supported below the usual sand hopper, and a plough or thrower is moved backwards and forwards between the mouth of the hopper and the plate to throw off the sand. A casing *a* formed as a continuation of the hopper *b* has a mouth or outlet arranged a short distance above the plate or shelf *c*, which is fixed in the lower part *d* of the casing. The thrower or plough *f* is pivoted in the casting so that it sweeps through an arc corresponding to or concentric with the curve of the curved plate *c*. This plough *f* is journalled at *g* g^1 at both sides in the casting, preferably at a point between the top casting *a* and lower casting *d* and is normally held by any suitable spring means, so as to lie at one edge of the curved plate. One of the ends of the plough *f* projects through from its bearing, forming a short shaft or spindle *g*. This short shaft is rigidly connected by means of a suitable link and arm to a rocking shaft across the under part of the car or vehicle, which rocking shaft is connected by means of another arm through suitable links and levers to the usual footlever. If it be desired to obtain a continuous flow of sand at times instead of an intermittent one as above described, the curved plate *c* can itself be mounted so as to swing about an axis preferably struck from the centre, from which the curved surface of the curved plate is described. In this case the bearings *h* for the curved plate *c* are arranged in exactly similar manner to the bearings of the cutter or plough *f*, except that they are made hollow so as to admit the shaft and bearings of the cutter inside them, that is to say the plate *c* and the cutter *f* are arranged to swing about the centre. (*Accepted 18th May*, 1908.)



Brake Mechanism. *16,097. 12th July, 1907. The Consolidated Brake and Engineering Co., Ltd., and E. S. Luard, Spencer House, South Place, London.*

According to the invention the push or pull-rod by means of which the brake-blocks are actuated either in hand brake mechanism, vacuum or atmospheric brake mechanism, is formed at its end with ratchet teeth *i j* on its upper and lower faces. With these two racks there engage respectively a pawl *k* and a detent *l*, the pawl and detent being held in engagement with their respective ratchet teeth by means of gravity or by springs. The pawl and detent are pivotally mounted upon the arm *c*, so that motion is trans-



mitted to or from the pull-rod through the medium of the pawl. Or, the double rack may be fitted or formed upon any other suitable part of the brake mechanism. With this arrangement when the wear of the brake-blocks or of the other connecting parts of the brake mechanism in course of time causes the movement of the pull-rod necessary for applying the brakes to be increased by an amount equal to the pitch of the teeth of the rack, then the detent springs forward one tooth in its rack and consequently causes the pawl on the return movement of the pull-rod also to engage with the next adjacent tooth, thus reducing the future stroke of the push or pull-rod by a length equal to the pitch of the teeth of the rack with which it engages. (*Accepted 14th May*, 1908.)

COMPLETE SPECIFICATIONS ACCEPTED.

1907.

11620. Sand baxes for tramway and railway vehicles. Anger.
11722. Rail seats and braces for railroad rails. Rose and Bell.
11769. Means of forming joints in railway or tram rails. Gillmor.
12238. Systems for electrically operating railway signals, points and the like. British Thomson-Houston Co. (Allgemeine Electrictats Ges.)
12697. Opening and closing apparatus for railway carriage windows. Jewson.
17347. Railway signalling apparatus. Kershaw and Saxby and Farmer, Ltd.
18780. Apparatus for ventilating railway carriages. Howard and Crighton.
28127. Railway sleepers. Boult (Gewerkschaft Deutscher Kaiser Hamborn).
9390. Electric vehicle or locomotive brakes. Simpson.
9885. Means for locking railway carriage doors. Hobson.
10001. Automatic railway signalling and train controlling apparatus. Kitson and Kellett.
10321. Apparatus for indicating or recording the time occupied by a locomotive train or other railway vehicle in passing over a measured length of road. Preston.
10687. Electrical block signalling system for railways. Brown.
11066. Dynamos for train lighting. Leitner.
11239. Air brakes. Lake St. Clair Air Brake Co.
13279. Brakes for tramway vehicles and the like. Simpson.
19819. Spark arresters for locomotives and other multitubular boilers. Stokeld and Black.
27894. Railway buffers. Gray.
10732A. Single rail vehicles. Davis, Meyer, Medhurst and Ferrar.
10793. Station indicators. Willis (Smith and Brown).
12646. Automatic couplings. Addis.
15602. Signalling systems for railway cars and the like. Lake (American) Railway Signal Co.

16097. Brake mechanism for railway and like vehicles. Consolidated Brake and Engineering Co., and Luard.
20017. Devices for operating railway points or switches. Rousseau.
27942. Locking mechanism for railway points. Brochner, Larsem and Krogh.

1908.

1107. Couplings for railway and like vehicles. Herrman.
1326. Railway rail joints. Wolhaupter.
2857. Railroad rail joints. Neuhard.
5290. Rail joint for railway rails and the like. Knuttel.
9552. Electrical block signalling apparatus for railways. Brown.
1698. Guards for railway vehicles. Sanford.
3779. Apparatus for controlling the supply of gas to railway carriages. Spencer.
5143. Railway trucks. Rohlfing.

Official Reports on Recent Accidents.

At **Shrewsbury Station, L. & N.W. and G.W. Joint R.** *On the 15th October. Lt.-Col. H. A. Yorke reports that:—*

The L. and N.-W. 1.20 a.m. passenger train from Crewe was derailed and wrecked, see fig. 1. There were about 70 passengers in the train, besides the driver, fireman, 3 guards, and 10 P.O. sorters. The driver and fireman, 2 guards, 11 passengers, and 3 P.O. servants were killed, and 61 injured, some severely.

The train consisted of a 4-6-0 passenger engine, 6-wheeled tender, and 15 vehicles (equal to 19½). The composition, weight, etc., of the train is shown by fig. 3.

The engine and tender were fitted with the steam brake, and the train with the continuous automatic vacuum brake, the two brakes being applied and released by the movement of one handle on the engine. Both brakes could also be applied in any one of the guards' vans.

The engine and tender were overturned on to their right sides; the two front vehicles of the train were demolished and buried beneath the wreck of the rest of the train; the third vehicle, G.W. compo. 1120, was close to Crewe Junction signal-box, about 20 yards from the rest of the train; the next six vehicles were more or less in a heap, piled up to a considerable height, some of them being smashed beyond identification, and the steel underfames so interwoven that it was necessary to cut them in pieces before they could be separated; the tenth vehicle was pressing against the heap of weckage, and damaged beyond repair; the next two vehicles were derailed and partly thrown over on to their sides; the next two were derailed and damaged; while the last vehicle of all was on the rails (see fig. 1.).

All the axles of the engine were bent. In other respects the damage done to the engine was less than might have been expected, the boiler and mechanism being practically uninjured. The tender was completely broken up.

The permanent way of two lines of rails was torn up and more or less destroyed for a distance of 140 yards (see fig. 2).

Shrewsbury Station is the joint property of the L. and N.W. and Great Western R. Cos., and for working purposes is under the control of a joint superintendent, and for maintenance, in the charge of a joint engineer.

The general arrangement of the junctions are shown by figs. 2 and 4. The route which the train should have followed was from the main line (from Crewe) to the up platform, in which case it should, after leaving the main line, have followed the curve of 610-ft. radius for a distance of 86-ft., then proceeded in a straight line for 44-ft., and finally taken the curve of 750-ft. radius (see fig. 2), and it should have passed through both junctions; but as it was derailed at the V crossing of the first junction, where the right-hand rail of the line on which the train was travelling intersects the left-hand rail of the up and down platform line, the curves and conditions beyond this crossing need not be further considered in this report. The points of both junctions were properly "set" and bolted for the up platform line, and the junction signals were all at danger.

The permanent way is G. Western standard; the rails 95-lbs. per yard; chairs 52-lbs. each, fastened to the sleepers by two ⅞-in. fang bolts; sleepers 2-ft. 6½-in. maximum distance apart, less at the joints, and at points and crossings. The switch rails at the facing points are 14ft. long, curved to a radius of 950ft., and the crossings are of a particularly strong description. The whole was relaid in 1903, and was in first-class condition.

The superelevation of the outer rails on the curves was small, as is usual at all such junctions, where it is always impossible to give the correct amount of cant. At the first set of facing points, the superelevation is said to have been ½-in.; at the V crossing between the right-hand rail of the up main and the left-hand rail of the up and down platform line, the superelevation was 1in.; at the next set of facing points, between the up main and up platform lines, it was 1½in.; at the V crossing between these two lines, 1½in., and from here to the station it became 2½in. These figures represent the maximum superelevation which it is possible to give at this place. For a curve of 610ft. radius, the superelevation, according to the usual formula, would be as follows:—0·6in. for 10 miles per hour; 2·46in. for 20 m.p.h.; 15·4in. for 50 m.p.h., and 22·2in. for 60 m.p.h. The speed of trains entering or leaving Shrewsbury Station and over the curve from Crewe Junction is not allowed by the Co.'s rules to exceed 10 m. an h.

The distance from the first set of facing points to the corresponding crossing is 70ft. The first mark was at the V point of this crossing, which had evidently received some severe blows. On the off side of the V, a piece about 6in. long had been sheared from the top, while the near side was bruised and damaged (see fig. 2). A mark was then found along the outer edge of the right-hand rail of the crossing, and numerous indentations or wheel marks were apparent on the top of the same rail, these having an oblique direction from right to left, the adjacent wing rail being also marked on the outside. Thereafter, the chairs of the right-hand rail of the up platform line, and the left-hand rail of the up and down platform line, became broken, and the corresponding ends of the sleepers of the two lines were scored, split, or crushed. At a distance of 70ft. from, *i.e.*, south of, the V crossing, there is a girder of an underbridge, about 12in. above the ballast. The corner of the girder nearest to the crossing was badly damaged. Some of the rivet heads on the top of the girder were damaged, and most of the bolt heads, which secured a face plate to the side of the girder nearest to the up platform line, were sheared off. The damage to the permanent way increased in severity until, at a distance of about 50 yds. from the crossing where the first mark appeared, both lines of rails, viz., the up platform line and the up and down platform line, were destroyed for a length of about 50 yds. (See fig. 2).

Fig. 4 shows the curvature and gradients of the L. and N.-W. R. from Crewe, for a distance of 5 miles north of Shrewsbury.

The points and signals of the junctions at the north end of Shrewsbury Station are worked from what is known as the Crewe Junction signal-box, 140 yds. south of the junction, and about 30 yds. from the north end of the down platform. The up home signals of this signal-box, of which there are 3, namely, for the up main, up platform, and up and down platform lines, respectively, are situated on the up side of the L. and N.-W. R., 66 yds. north of the first of the facing points, being placed in that position in order to protect a cross-over road between the up and down L. and N.-W. lines, which is between the signals and the facing points. All these signals were at danger. The interlocking is correct. The next signal-box, 600 yds. northwards of Crewe Junction, is Crewe Bank box. Here the signals referring to the up line are distant, home, and starting, there being also outer and inner distant signals (each with a single arm) of Crewe Junction box fixed respectively on the same posts as, and below, the two latter; the two distant signals of Crewe Junction are fixed at danger, and the regulations for working the traffic are such that the distant signal of Crewe Bank is never lowered. The next signal box, viz., Harlescott crossing, is about ¾ mile from Crewe Bank, and has distant and home signals; and the next is Hadnall Station, about 2¼ miles north of Harlescott crossing.

The signals are all on the left-hand side of the line, *i.e.*, on the driver's side of the engine.* They are good conspicuous signals, easy to see, and easy to read, and the lights are said to have been burning properly on the night of the accident. The usual place for drivers to begin to slow down and check the speed of their trains is said to be about ½ mile north of Crewe Bank outer distant signal, or 1,941 yards from the site of the accident.

All the signals were "off" for the train as far as Crewe Bank, but here, and at Crewe Junction, they were at danger. The reason for this was that as the platform line at Shrewsbury to which the train was to run was already occupied by a previous train, with which the Crewe train had to connect, the Crewe Junction signalman had accepted the latter train from Crewe Bank under "Section clear but station blocked," and it was therefore the duty of the Crewe Bank signalman to stop the train dead, and verbally give the caution to the driver. The train should then have proceeded cautiously to the home signals of Crewe Junction, one of which would eventually have been lowered to allow the train to enter the station at the authorised speed of 10 miles an hour.

Fig. 3 gives particulars of the engine, which was one of the "Experiment" class, and has a leading "radial truck." This is similar in most respects to a bogie, but also possesses some features in common with Webb's well-known "radial axle." The radial truck allows a limited amount of lateral or side play, in addition to the turning movement; which is not the case with a bogie fitted with a centre pin only.

The engine was fitted with an air pump, connected to one of the cross-heads for maintaining the vacuum. There were six sand boxes on the engine, five of which were found to be intact and filled with sand after the accident. The other had been carried away.

The engine was turned out of the shops new in December, 1906, and commenced running on the 15th January, 1907. It is said to have run 55,857 miles up to the date of the accident. It went into the shed at Crewe for a general overhaul between the 30th September and the 10th October, 1907, and the following repairs were done to it, namely:—wheels turned up, axle boxes re-fitted on journals, connecting rods examined, new brasses fitted on big end, copper stays and fire-box re-riveted, tubes examined, and other minor details attended to. After completion of the repairs, on the 11th October, the engine was given a trial run to Whitmore and back, when, everything being satisfactory, it was put into service the same evening, working from Chester to Crewe and back. On the 12th October it worked a train to Birmingham, and returned light to Crewe, and subsequently worked a special train from Crewe to Batley, and again returned light to Crewe. On the 14th October it worked the 2.5 a.m. train from Crewe to Holyhead, returning in the evening with the 6.50 p.m. train from Holyhead to Crewe, due at the later place at 11.50 p.m.

*The practice on the L. & N.W.R. is to "drive" from the left-hand side of the footplate.

At 1.28 a.m. on the morning of the 15th October it left Crewe with the train to which this accident occurred. It had, therefore, only been at work for four days, since the completion of the repairs, when this accident happened.

All the vehicles were either built or repaired within the last twelve months, it may be taken in the absence of any evidence to the contrary that they were in good condition.

The weight of the train, exclusive of the engine, was 289 tons, of which all but about 23 tons was carried upon braked wheels. The weight of the engine and tender was, as already stated, 102 tons 15cwt., of which all but 19 tons was carried upon braked wheels. The total weight of the train, inclusive of engine and tender, was therefore 391 tons 15 cwt., of which 349 tons 15 cwt. was braked. (See fig. 3).

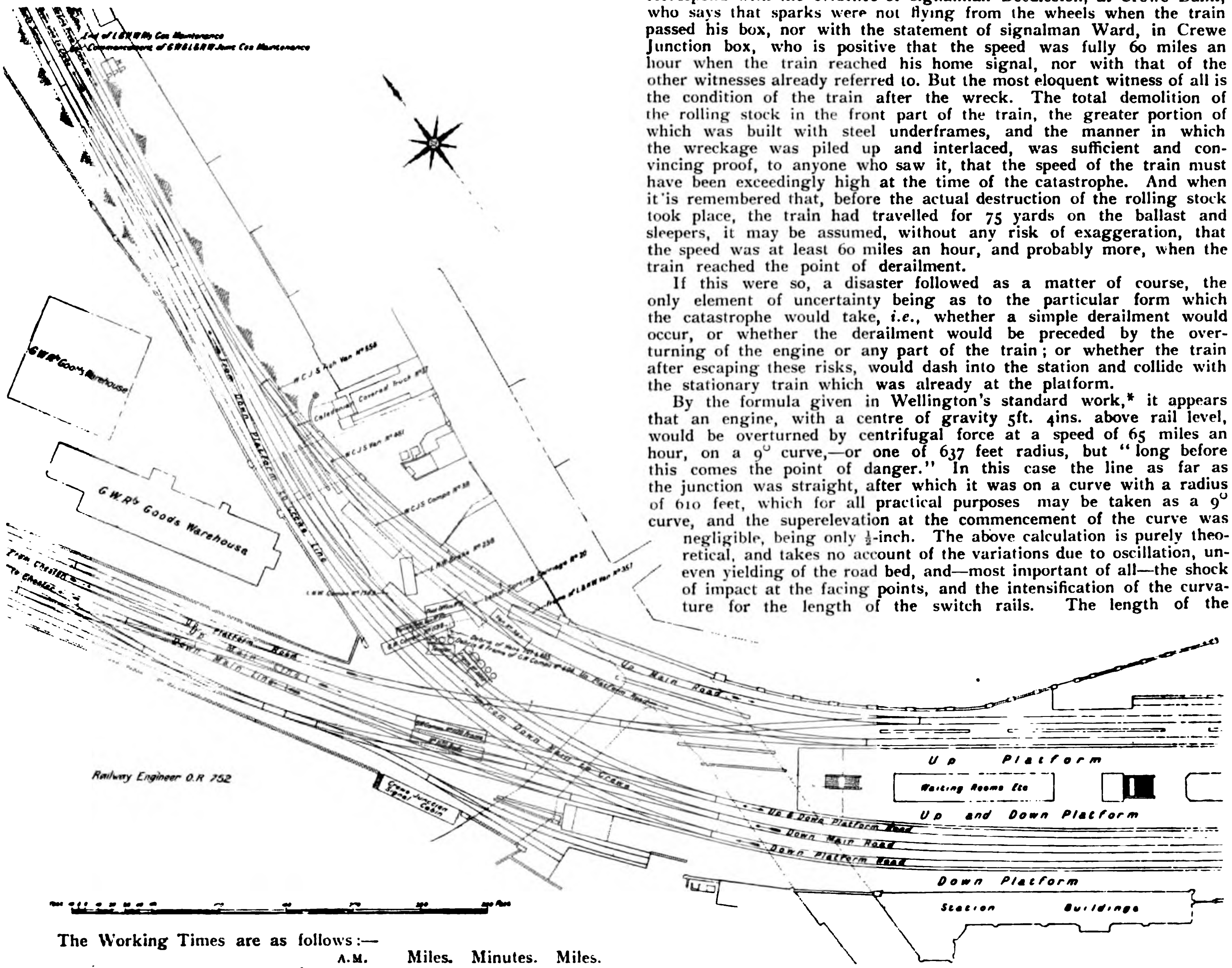


Fig. 1.

The Working Times are as follows:—

	A.M.	Miles.	Minutes.	Miles.
Crewe ... ... dep.	1.20			
Nantwich ... ... pass	1.27	4½	7	4½
Whitchurch ... ... ,,	1.41	13¾	14	9⅜
Shrewsbury ... ... arr.	2.5	32⅝	24	18⅞

The average speed is therefore 43·5 miles per hour.

It will be seen from the Schedule that, whereas 14 minutes are allowed for the 9⅜ miles between Nantwich and Whitchurch, equivalent to a speed of 40 miles an hour, only 24 minutes are allowed for the 18⅞ miles between Whitchurch and Shrewsbury, including the time required for slowing down and stopping at the latter place. Allowing 3 minutes for the last 1½ miles, *i.e.*, from the 31st mile post (near which it is the custom of drivers to begin to slow down) to Shrewsbury Station, it will be found that the average speed from Whitchurch to the 31st mile post must be about 50 miles an hour. But this is subject to fluctuation owing to the gradients, especially with a heavy train such as the present one, and it may be reasonably assumed that on the falling gradients from Hadnall the speed is always considerably above this figure.

The train left Crewe 8 minutes late, and was still 8 minutes late at Whitchurch. The driver made up 5 minutes between Whitchurch and Shrewsbury. It therefore appears that the train took 19 minutes to cover the distance of 18⅞ miles between Whitchurch and Shrewsbury, which is approximately equivalent to a speed of 60 miles an hour. This is in agreement with the evidence of the signalmen in Crewe Bank and Crewe Junction signal-boxes, the former of whom says that the train passed him at 60 miles an hour, and the latter—that the train was travelling at a "terrific speed—60 miles an hour," when it was passing his home signal, immediately before the accident. Several other witnesses also testified to the excessive speed of the train as it approached the junction. Guard Birch says that when the train was passing Crewe Bank distant signal, the speed was 60 miles an hour, that he observed that the vacuum brake had been applied somewhere between the distant and home signals of Crewe Bank box, and that the speed was reduced to 40 miles an hour before the derailment occurred. The last part of this statement does not correspond with the evidence of signalman Beedleston, at Crewe Bank, who says that sparks were not flying from the wheels when the train passed his box, nor with the statement of signalman Ward, in Crewe Junction box, who is positive that the speed was fully 60 miles an hour when the train reached his home signal, nor with that of the other witnesses already referred to. But the most eloquent witness of all is the condition of the train after the wreck. The total demolition of the rolling stock in the front part of the train, the greater portion of which was built with steel underframes, and the manner in which the wreckage was piled up and interlaced, was sufficient and convincing proof, to anyone who saw it, that the speed of the train must have been exceedingly high at the time of the catastrophe. And when it is remembered that, before the actual destruction of the rolling stock took place, the train had travelled for 75 yards on the ballast and sleepers, it may be assumed, without any risk of exaggeration, that the speed was at least 60 miles an hour, and probably more, when the train reached the point of derailment.

If this were so, a disaster followed as a matter of course, the only element of uncertainty being as to the particular form which the catastrophe would take, *i.e.*, whether a simple derailment would occur, or whether the derailment would be preceded by the overturning of the engine or any part of the train; or whether the train after escaping these risks, would dash into the station and collide with the stationary train which was already at the platform.

By the formula given in Wellington's standard work,* it appears that an engine, with a centre of gravity 5ft. 4ins. above rail level, would be overturned by centrifugal force at a speed of 65 miles an hour, on a 9° curve,—or one of 637 feet radius, but "long before this comes the point of danger." In this case the line as far as the junction was straight, after which it was on a curve with a radius of 610 feet, which for all practical purposes may be taken as a 9° curve, and the superelevation at the commencement of the curve was negligible, being only ½-inch. The above calculation is purely theoretical, and takes no account of the variations due to oscillation, uneven yielding of the road bed, and—most important of all—the shock of impact at the facing points, and the intensification of the curvature for the length of the switch rails. The length of the switches in this case is 14ft., and they are curved to a radius of 950ft. This curvature of the switch is provided for the purpose of reducing the shock due to the sudden transition from the tangent on to the curve. But at all such junctions, "the abrupt divergence from the straight line, which takes place in such a length, is more than twice as great as the tangential divergence which occurs in the same length on the sharpest curve in ordinary use on railways."† The divergence in this case is 4¼in., viz., 1⅞in. between the stock rail and the switch rail (that being the space required to allow the flanges of the wheels to pass between the two rails) + 2⅜ inches, which is the width of the head of the switch rail. This divergence, in a length of 14ft., is equivalent approximately to that of a curve of 4 chains radius (264 ft.), and although the curving of the switch rail to a radius of 950ft. has undoubtedly the effect of reducing the shock caused by the sudden

*The Economic Theory of Railway Location, by (the late) A. M. Wellington, New York.

†Railway Appliances, by Sir John Wolfe Barry, K.C.B., &c.

transition from the straight, it does not alter the fact that the divergence in a distance of 14ft. is necessarily equivalent to that of a curve of exceedingly short radius, on which overturning would occur at a speed of 40 miles an hour. The curve given to the switch rail is not a true transition curve, that is to say, it is not, and cannot be, tangential to both the stock rail at the point of the switch, and the curve of the line at and beyond the heel of the switch, and although it doubtless reduces the shock of impact, and increases the comfort of passengers, it does not justify any considerable increase of speed through the junction.

For these reasons it is evident that at a junction such as this overturning would take place at a speed considerably below 65 miles an hour. By the regulation of the joint companies the speed through the junction is fixed at 10 miles an hour, and this is not absolutely safe, but does away with all feeling of discomfort on the part of the passengers. It has also to be noted that, not only the junction signals were at danger, but also the starting, home and distant signals of Crewe Bank box, the home signal being 527 yards, and the distant signal 1,403 yards from the junction. The train should therefore have come to an absolute stop at Crewe Bank, 527 yards from the junction, and should have afterwards proceeded cautiously

centrifugal force. In this way each wheel of the fore part of the train in succession took the wrong side of the point of the V of the crossing, and derailment immediately commenced. The moment that this occurred the action of centrifugal force ceased, the overturning movement was arrested, and the engine, probably, took a course tangential to the curve it had just left. The rest must be largely a matter of conjecture. From the manner in which the permanent way was affected, it is certain that the train became "split," part of it following the left (or up platform) road, and part the right (or up and down platform) road. The fact that all the coaches but one were found between these two lines, and several of them in a position transverse to the lines supports this view. The engine followed a straight course between the lines, with its left-hand wheels travelling for some distance on the sleepers of the up platform line, and its right-hand wheels on the ballast between the two lines. In this manner it probably scraped by the north face of the girder, to which reference has been already made, shearing off as it did so the heads of the bolts projecting therefrom. After passing this, its wheels got deeper and deeper into the ballast, causing it finally to overturn on to its right side. That the engine did not travel far after it was overturned is proved by the fact that the bodies of the driver and fireman

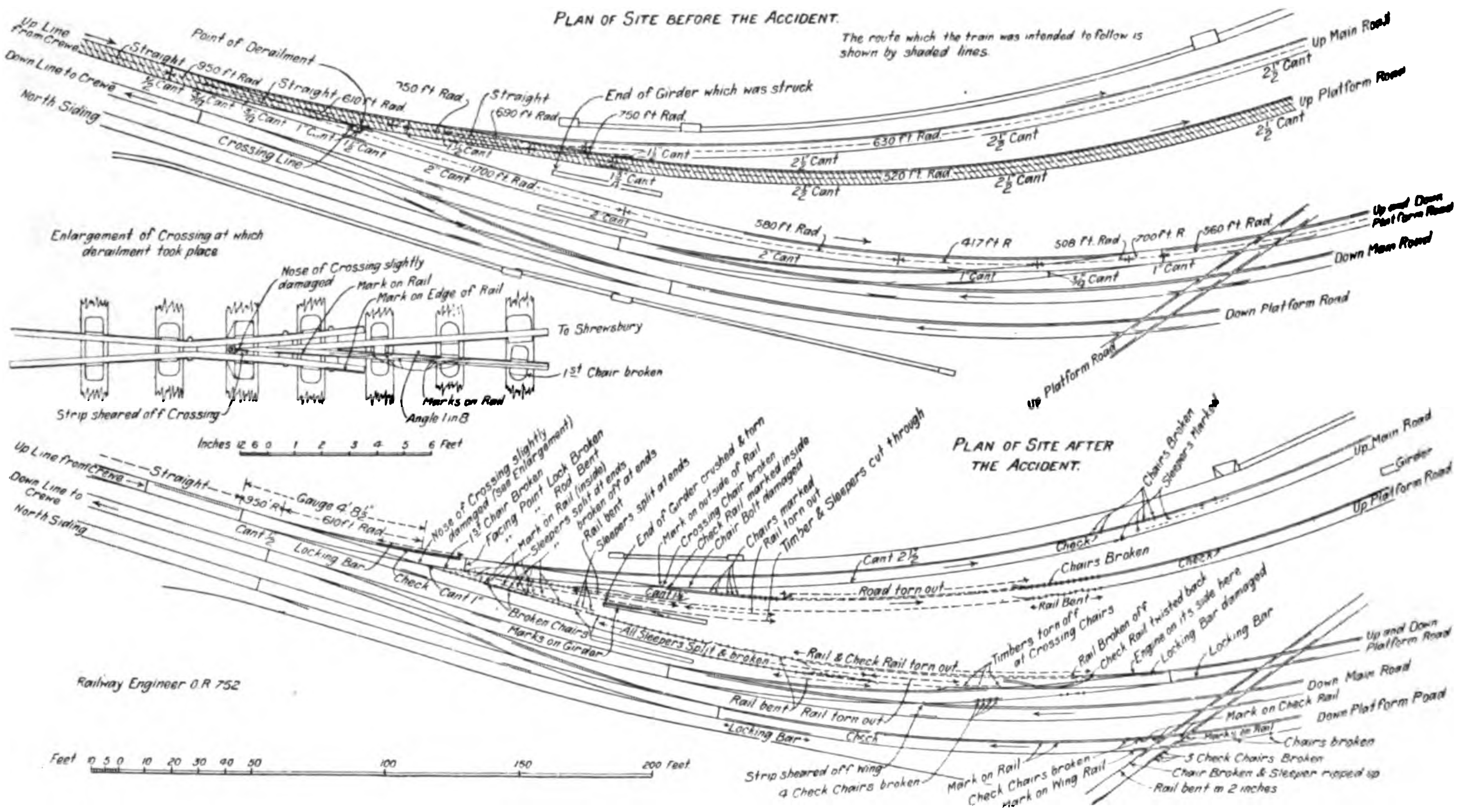


Fig. 2.

to the junction, where the speed should have been 10 miles an hour. But it has already been shown that the actual speed of the ill-fated train was at least 60 miles per hour when it reached the junction, and danger at once became imminent. What probably happened was this. The wheels of the engine when passing through the facing points were suddenly deflected to the left, this being the direction of the curve, while the direction of motion of the mass of the engine was straight, and tangential to the curve. This caused the engine to give a heavy lurch, and to commence to fall over towards the right, thus lifting the left-hand wheels off the inner rail of the curve, while the right-hand wheels were pressed hard against the outer rail, the pressure being divided between the two bogie wheels and the rear wheel of the engine. Seventy feet from the junction there is the usual gap in the right-hand rail of the curve, where this rail intersects the left-hand rail of the straight line, which gap would be reached by the engine (travelling at 60 miles an hour) in less than a second. At moderate speeds, the wheels of vehicles passing through such a crossing are guided by the check, or guard rail which is fixed opposite the crossing alongside the other rail of the track; the effect of the guard rails being to keep the wheels at one end of an axle in the proper course, while the wheels at the other end of the same axle are passing over the gap. But in this instance the left-hand wheels of the engine would, as stated—owing to the commencement of the overturning movement of the engine—be lifted off their rail, and the guiding effect of the check rail would be lost.

There was nothing therefore to prevent the right-hand wheels, first of the radial truck, and subsequently of the engine and train, from being deflected to the right, as they crossed the gap—on the contrary they were certain to be so deflected, under the influence of

were found on the engine, and also by the superficial nature of the damage done to the lagging of the boiler, which was merely scratched. The framing of the engine probably became entangled in the permanent way, which caused it to come abruptly to rest with its front end 100 yards from the crossing where the derailment took place. The engine thus acted as a "stop" to the rest of the train, with the result that "telescoping" of the leading vehicles occurred, and the wreckage was piled up in a heap. The engine was followed by the tender, and probably also by the two leading coaches, which were buried beneath the wreckage immediately behind the tender. The third coach was thrown clear of the rest of the wreck, being found about 35 feet south of the engine, close to the Crewe Junction signal-box. This coach was one of those that followed the up and down platform line; but how many others did the same thing, or which coaches battered the end of the girder between the two lines, it is impossible to say. A remarkable feature about the occurrence is the manner in which, in spite of the "splitting" of the train, all the vehicles of the front portion of the train with one or two exceptions came together and were piled up in a heap, while the rear vehicles were heading for the heap, with the exception of the last, which passed safely through the crossing and remained on the rails. In fact, from the position in which the vehicles were found, it would at first sight seem as though the train had, with the exception of coach 1,120, followed the engine in a direct line, but, judging from the destruction of the two diverging lines of rails on either side of the wreckage, this cannot have been the case. What caused the final concentration of the vehicles cannot be explained, but it points to the fact that the couplings held until the very last moment. (See fig. 1).

The following salient facts are not to be disputed:—(1) the train

was travelling at an excessive speed when it reached the junction; (2) the derailment took place at the V crossing between the up platform line and the up and down platform line; (3) the train was "split" at this place, part taking one line, and part the other; (4) the engine came to a stop in 100 yards from the point of derailment, or in less than half the length of the train; (5) the abruptness of this stop, combined with the initial speed at the moment of derailment, sufficiently account for the long death roll and the wholesale destruction of rolling stock, which mark this catastrophe as among the worst which have occurred on English Railways.

It not infrequently happens that derailments are caused by weakness or other fault in the permanent way. But in this instance it may be said at once that the permanent way was of the best and strongest description, and in no way can the derailment be attributed to any defect in it.

Suggestions have been made to the effect that the brakes on the train must have "failed," and this appears to have been the view taken by the Coroner's jury, who, after a verdict of "Accidental Death," added a rider "that the brake power of the train was insufficient." The jury heard no evidence regarding the braking power of the train, and on such evidence being tendered by the Solicitor of the L. and N.-W. R. Co., they declined to receive it. Nor is it clear different companies, were in such a condition as to be totally unserviceable.

In the absence then of any evidence to the contrary, it may be taken that the brakes in this train were in ordinary working condition, and of the usual degree of efficiency, and were sufficient to have controlled the train and brought it to rest at the signals at both Crewe Bank and Crewe Junction signal-boxes, had they been applied in sufficient time.

Another suggestion that has been made is that the driver was unable to close the regulator valve. This might happen in any of the following ways:—(a) the breaking of the rod or of any of the connections between the regulator handle on the footplate, and the valve; (b) by some defect in the regulator valve inside the boiler; or (c) by the seizing of the rod by the gland packing, where the rod passes through the face plate of the boiler over the fire-box door. As regards (a) and (b), the examination of the engine after the accident by Mr. Main, M.I.Mech.E. (Assistant Inspecting Officer, Board of Trade), showed that the rod or spindle, and the connections between the handle and the valve, were unbroken and perfectly sound. For the purpose of this examination the dome was lifted and the whole of the gear removed. The regulator valve is of the Ramsbottom double seated type, the opening and closing of it being effected by

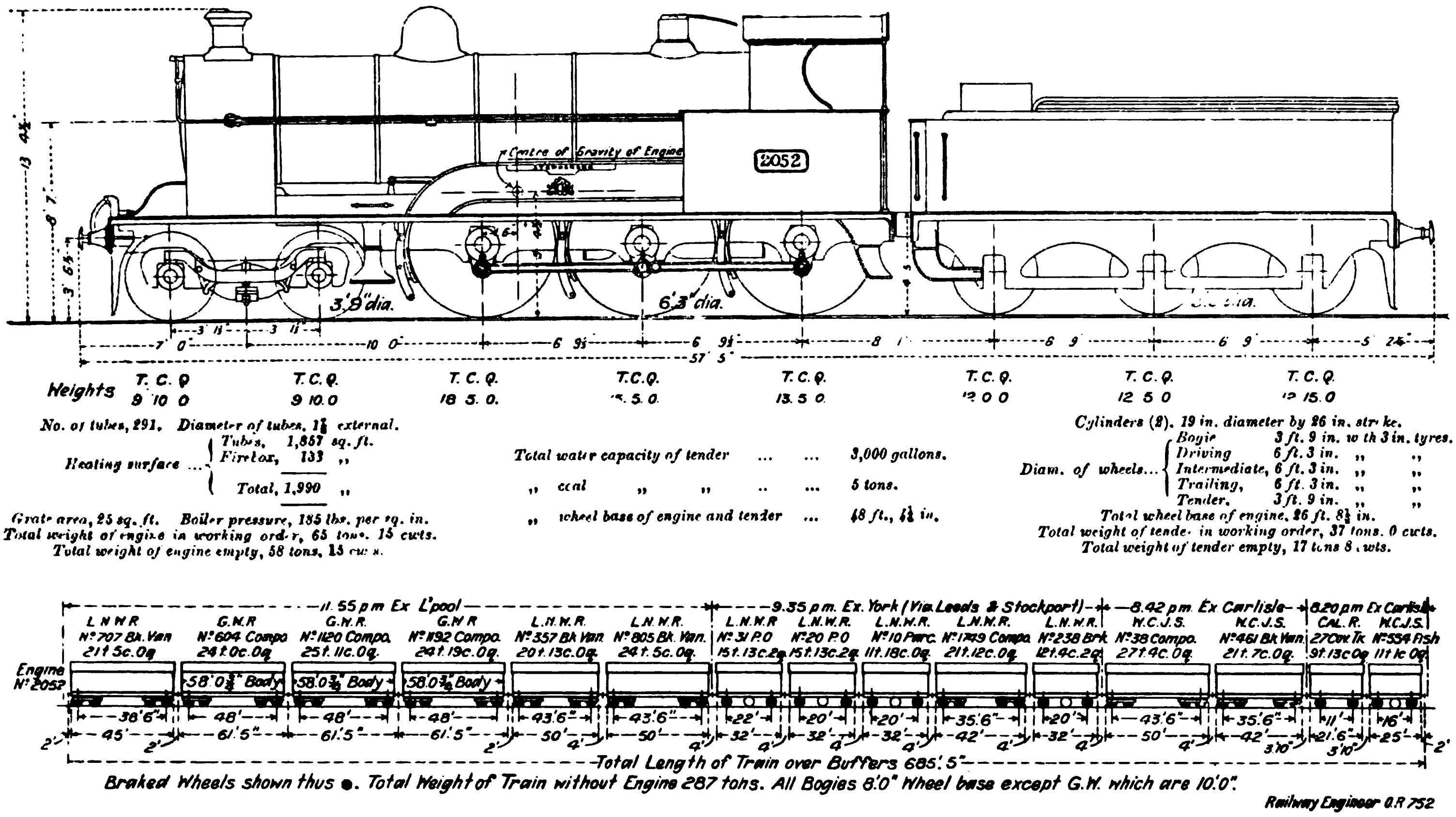


Fig. 3.

what is meant by the statement that the brake power was "insufficient."

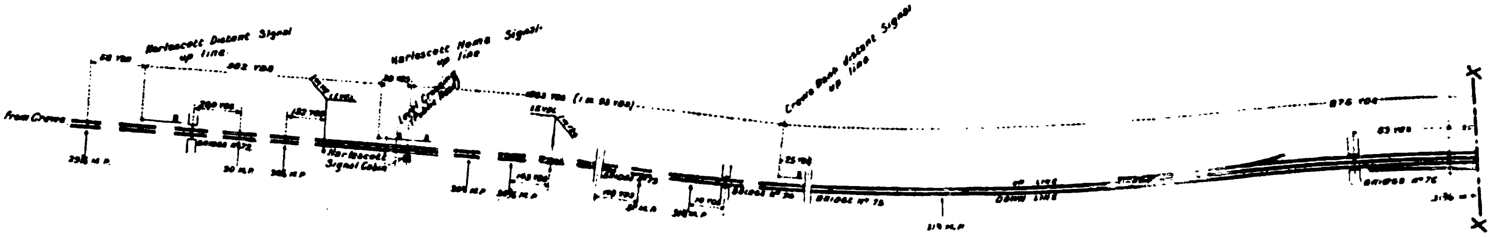
It is a very easy thing at all times to say that the brakes "failed," and very difficult to disprove, and such suggestions, if not based on positive evidence, require the closest scrutiny. There is no possibility of the centrifugal force having had any effect on the ball valves. The various vehicles on the train had respectively several patterns of vacuum brake, chiefly those in use on the L. and N.-W. and the G.W. Railways.

Guard Birch, who was in charge of the train, and was travelling in the rear brake van, says that the brakes were tested in the usual manner, and in accordance with the regulations, before the train left Crewe. It is more than probable that in a long train the brake blocks do not all move with the same degree of rapidity and pressure, and that the actual braking power at the driver's disposal is less than that theoretically available. This would be due to one or other of the following causes:—(a) the existence of cracks or leaks in the rolling rings or diaphragms, or (in the case of G.W. stock) of the valvular piston ring, all of which are made of vulcanised rubber, and liable to deterioration, such cracks causing a leakage between the upper and lower sides of the brake pistons; (b) worn brake blocks or slack brake rigging. Some such defects are ever present to a certain extent, except perhaps in the case of absolutely new rolling stock, but it is in the highest degree improbable that the whole of the brakes or the majority of them on this train, composed as it was of comparatively new, or recently repaired stock of different types and belonging to raising and lowering the valve in a vertical direction by means of an eccentric attached to the rod or spindle, which passes horizontally through the boiler, from the regulator head to the handle outside the boiler face plate. Everything connected with the valve was found in good order, and close fitting. As regards (c), if any such seizing occurred, it would be due to want of proper lubrication, for which the driver was responsible. But, even supposing that the regulator was stiff, the fact that the regulator handle was found shut after the accident upsets the suggestion that the driver was unable to close it. Driver Martin had taken the same engine to Holyhead and back, and if he had had any difficulty with the regulator he would have had an opportunity of speaking about it at Holyhead or Crewe, and having it rectified. For these reasons, there does not appear to be any ground for supposing that the regulator was out of order, or that the driver was unable to close it.

There is another possibility, and that is that the gauge glass broke, and that the enginemen were driven off the footplate by the escape of steam and scalding water. The gauge was indeed found broken after the accident, but the fracture was probably the effect and not the cause of the disaster. The gauge glasses on the engines of the L. and N.-W. R. have efficient protectors, and are also fitted with automatic "shut off" valves, both at the top and bottom, which instantly close the connections between the boiler and the gauges, should the latter become broken, so that if any accident occurred to the gauge the enginemen would have been in little or no danger from steam or water.

All the above arguments point to the extreme improbability that the disaster was due to any defect in the permanent way or mechanism of the engine or brakes. If that is so the cause must be sought elsewhere.

Driver Martin was an experienced man. He entered the Company's service in 1871 as cleaner, and had worked his way up through the various grades of cleaner, fireman, extra driver (1898), goods and local passenger driver (1899), until in 1904 he became express driver. He was in his 52nd year, and is said to have enjoyed good health. There is no reason for supposing that his sight was bad, or that he suffered from colour-blindness. His eyesight is said to have been last tested in February, 1907. He was not a teetotaler, but was described as a sober man. His record of service for the last ten years shows 13 entries: 4 for running by stations at which he was booked to stop, 2 for passing signals at danger, 5 for being absent without leave, or missing his train, and the other two for losing time, or allowing his engine to emit clouds of black smoke in a station. All these faults occurred between the years 1896 and 1905; two of them ("absent without leave," and "missing his train") while he was a fireman, and the remainder after his promotion to driver, the last entry of all (viz., "passing Standon Bridge Station, where he was timed to stop") being dated October 4th, 1905.



Martin's excuses for passing the stations at which he was timed to stop were the same in each case, namely, that he had misread his Working Time Book, while, as regards passing signals at danger, he stated in one instance that he missed seeing the distant signal (although it was a clear night), and therefore failed to stop at the home signal, and in the other, that although the distant signal was at danger, the home signal was "off," and he consequently failed to stop at the starting signal. As a rule the punishment awarded was one or two days suspension from duty, but in the last case the suspension extended to three days.

Such a record can hardly be regarded as a very good one, and indicates, to put it mildly, an occasional lack of attention on Martin's part to his duties.

Fireman Fletcher, who was in his 30th year, had been in the Company's service since 1897, first as cleaner, and since 1904 as fireman. He bore a high character, and is said to have been a "strict teetotaller." Many witnesses testified to his steady, sober, and thrifty nature. He had returned from his annual holiday on the previous day, and this was the first job he had to do since his return. He was employed as extra fireman, and was, therefore, accustomed to work on all sections of the L. and N.-W. R., but he had never previously "fired" for driver Martin.

Driver Martin and fireman Fletcher came on duty at Crewe on Sunday, the 13th October, at about 8.15 p.m., to work the 9.22 p.m. train, Crewe to Manchester. They returned from Manchester to Crewe at 10.47 p.m., and they then worked the 2.5 a.m. train from Crewe to Holyhead, arriving at the latter place at 5.19 a.m. on Monday morning, the 14th. After taking their engine to shed, they left work at about 6 a.m., and proceeded to the lodging-house near the station, which is provided by the L. and N.-W. Co. for the use of their men. It is obligatory on all the men to make use of this lodging-house when booked off duty for the purpose of taking rest, instead of taking lodgings in the town, and a book is kept in the house in which the men have to sign their names, both on arrival and departure. There is also a board provided on which the number of each man's room is entered and the time at which he wishes to be called. The lodging-house is in charge of a matron in the daytime, and of a watchman during the night. It contains bedrooms, bathrooms, lavatories, mess-room, and conveniences for cooking or warming the food brought into the place by the men. No intoxicating liquors are obtainable in the house, but there is nothing to prevent a man bringing anything of this sort into the house should he so desire, for consumption with his meals, and there is no reason why he should not do so when off duty for a whole day, as in this case, so long as the quantity is moderate.

Night-watchman Higgins saw Martin and Fletcher arrive at the house at six, and Miss Williams, the matron of the house, saw Martin between 8 and 9 a.m. in the dining room, but one saw them have their breakfast or go to their rooms. No definite evidence is forthcoming to show how the men passed the day, but Miss Williams, when about the house during the day in the course of her duties, observed that the door of the bedroom (No. 15) allotted to Martin was closed, and heard breathing as though someone was sleeping therein. It may therefore be assumed that they spent part at least of the time in bed. Neither of the men was seen by anyone in the house till about 7 p.m., when Martin was having his tea. Fletcher is said to have had his tea and left the house earlier than this. Nightman Higgins, who came on duty again at 7 p.m., and driver Davenport, who was in the house, state that they had some conversation with Martin while he was at his tea, and that in answer to their enquiries he said that he had had a "good" or "quiet day" in bed. They both say that he took away some tea with him in a bottle, which he filled from the teapot; but at this point there is a discrepancy in their evidence, Higgins saying that Martin's bottle was "an ordinary bottle or stone jar," and Davenport, that it was a "little glass bottle" similar to a mineral water bottle. As a matter of fact the bottle which was subsequently found with driver Martin's name on it was a stone bottle such as is usually possessed by drivers.

At 7.25 p.m. Martin left the house and went to the engine-shed to join his engine, and at 8.50 p.m. he and Fletcher left Holyhead with the parcels train for Crewe, where they arrived at 11.50 p.m. At Crewe there was an interval of 1½ hours before they were due to leave with the 1.20 a.m. express train for Shrewsbury. This interval seems to have been occupied, firstly in disposing of the Birmingham and Crewe portions of the Holyhead parcels train, which were put into No. 6 bay; secondly, in shunting a horse box and a fish truck into the down carriage sidings; and lastly, in crossing from the carriage sidings to No. 4 platform, where the Shrewsbury train was standing. This last movement seems to have taken some little time, as the engine had first to go from the carriage sidings at the south end of the station to the North Junction box, and then back again to the south end, along No. 5 up line, in order to enable it to reach No. 4 platform line, and Martin is said to have expressed to Inspector Cook some anxiety lest he should be late in getting on to his train. The engine was coupled on to the train at 1.18, and, as soon as this was done, the brake is said to have been tested in the usual manner by the rear guard. The train left at 1.28, the delay (8 min.) in starting being due to causes for which Martin was not responsible.

Martin was well acquainted with the line between Crewe and Shrewsbury, having worked trains over it constantly since 1903. He had also taken the 1.20 a.m. train from Crewe to Shrewsbury as recently as the morning of Saturday, the 11th October. In April and again in October, 1907, he had signed the "road book," stating that he knew the section, and had been over it during the previous six months, and he was in possession of the General Rule Book, Working Time Book, Appendices, etc., etc., the latter containing the regulations as to reduction of speed at various places, including the entrance to Shrewsbury Station. He is said to have been very particular in his care of these books, and kept them in a leather wallet which he carried in his basket.*

Fireman Fletcher is also said to have known the road to Shrewsbury, as, being an extra fireman, he had to be prepared to work with trains to any place. But his usual occupation was that of a "cleaner," and though he had a General Rule Book, he was not supplied with the Working Time Book and Appendices, etc. His knowledge of the road must, therefore, have been inferior to Martin's.

There is nothing to show that driver Martin was aware of his position and danger when he passed Crewe Bank box. Had he been so, it is almost a certainty that he would have been blowing his brake (or danger) whistle, or would have made some attempt to attract the attention of the signalman, or of the guards of the train, to his difficulties.

Guard Birch says that somewhere between Harlescott Crossing and Crewe Bank box his attention was attracted to the high speed of the train, and that he then looked out of the window and saw the distant signal of Crewe Bank at danger. He then went to the brake valve in his van for the purpose of applying the brake, but found that the vacuum in the train pipe had been destroyed, and that the indicator of the gauge was pointing to zero, showing that the brakes had already been applied. It must be remembered that in saying this Birch is only repeating what he ought to have done according to the rules, and there is no corroboration of his statement. On the contrary, the statement of signalman Beedleston at Crewe Bank, though not conclusive, indicates that the brakes were not on the wheels of the train as it passed his box. There was a lot of steam about the engine, but he saw no sparks from the wheels. But it appears that soon after passing Crewe Bank box Martin realised his position. The evidence of police-constable Price, who saw the train a short time before it reached the junction, and of Mr. Evans, who heard it, goes

*Neither books, basket, or wallet have been forthcoming since the accident. Two baskets were picked up, but only one of them, which has been identified as the fireman's, was preserved. This contained nothing but a cloth and some scraps of food. The other basket disappeared, but, judging from the evidence of shedman Bellingham, it in some way or other got back to Crewe, and was burnt.

to prove that the driver sounded his whistle a few times about half-way between Crewe Bank and Crewe Junction signal-boxes. Other evidence points to the probability that the brakes were applied and the engine reversed before the junction was reached. This is confirmed by the fact that the brake handle on the engine was found in the "on" position, and the reversing handle in back gear, when the engine was examined after the disaster.* All these facts indicate that the brake was applied and the engine reversed after passing Crewe Bank box, or in other words, *when it was too late*. And it is probable that Birch went to the brake valve for the purpose of applying the brake, when the train was between Crewe Bank and Crewe Junction, and not, as he says, before it had reached Crewe Bank.

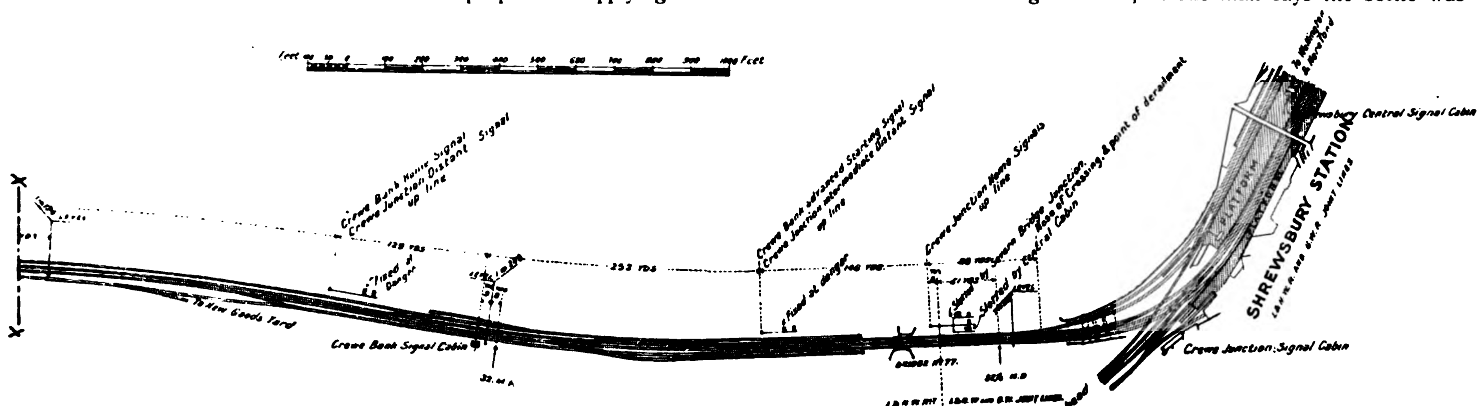
The all-important question at once arises as to how it happened that the train was allowed by Martin not only to run past two signal-boxes, the signals of which were at danger, but also to approach the junction at such an excessive speed. The first thought that leaps to the mind is that the driver must have had a sudden attack of illness, or a fit of some sort. The testimony of his friends and acquaintances showed that Martin was a healthy man, in the prime of life, stoutly built, and weighing about 14 stone, and one who had never exhibited any tendency to fainting or physical collapse. In order to clear up any doubt on this subject, the Coroner ordered a post-mortem to be held on his body. The evidence before the Coroner of the surgeons who conducted the post-mortem (Doctors Bulstrode and Jackson) is to the effect that the heart, brain, and liver of Martin were healthy, and that there was nothing to indicate that he had had, or was liable to, any such attack of sudden illness.

Another obvious question arises, and that is whether Martin was sober. This is an unpleasant subject, especially as the unfortunate man is dead and cannot speak for himself. Several letters have been addressed to the President, suggesting drunkenness as the cause of this and similar disasters. Many of these letters come from men who have served on the footplate, others from medical men who have had engine-men under their professional treatment. Martin was not a teetotaller, and, in the interests of the public, searching enquiries into Martin's life and habits have been made at Crewe and other places. Nothing, however, has been elicited which would throw any light in this respect on the disaster, and so far as can be ascertained, Martin has never been known to have exhibited any signs of intoxication when on duty. During Monday, the 14th October, he had spent 13 hours at Holyhead, and, as already stated, no one can be found who saw Martin from about 8.30 a.m. till he had his tea between 6 and 7 p.m. Two men say that they then saw him fill a bottle with tea to take with him on his engine. But, as one man says the bottle was of glass, and the other that it was of stoneware, the value of their evidence is considerably discounted. Martin's bottle was found on, or near, the engine after the accident by a man named Adamson, who showed it to locomotive foreman McClellan, and by the latter's orders put it away in his (McClellan's) compartment in the break-down train. It was afterwards transferred to McClellan's office at Shrewsbury, and kept there under lock and key until the third day of the inquiry (22nd October), when it was produced. McClellan told no one of the finding of the bottle except locomotive foreman Nash. It was a stone bottle, with Martin's name stamped upon the brass handle attached to it, and it was further identified as Martin's by fireman Powell, who had formerly regularly worked with Martin. When produced, it was absolutely clean, both inside and out, and the brass handle had evidently been very recently polished. It had no cork or stopper, and there was no smell of tea, coffee, beer, or spirits about it. McClellan admitted that the bottle had been in his possession since it was found, and, in the first instance, said that it was in the same condition as when it was found. But it was subsequently ascertained that during the time the bottle was in McClellan's possession it had been washed and cleaned. Both Nash and McClellan committed a grave fault in not reporting to their superiors the fact that the bottle had been found, and McClellan was further to be blamed for allowing the bottle to be washed while in his possession. The misconduct of these men did not result in any material fact being withheld.

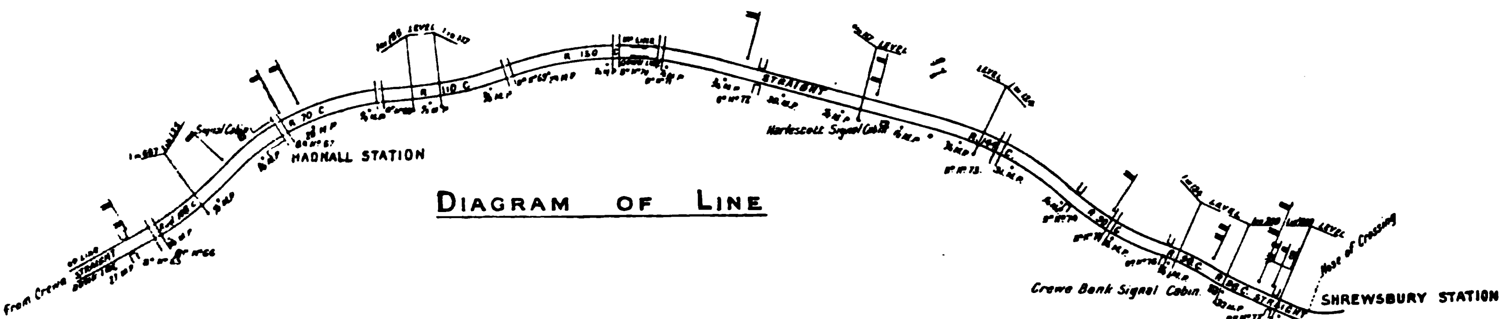
The contents of Martin's stomach were forwarded by Dr. Bulstrode to London for analysis by Sir Thomas Stevenson, M.D., Official Analyst to the Home Office. Sir Thomas Stevenson's report stated that, besides solid food, the stomach contained a liquid ounce of brown fluid which was not identified, but which possessed no odour or signs of malt or spirituous liquor. The examination which took place on the 23rd October, *i.e.*, the eighth day after the accident, clears Martin from the suspicion of having been drunk when he went to his death.

One other possible explanation of the accident, and that the simplest of all, remains to be considered—were either or both of the men on the engine asleep or dozing? It is not to be supposed that anyone who has had any experience "on the footplate" will deny the possibility of such a thing happening.

It is an admitted fact that the early hours of the morning

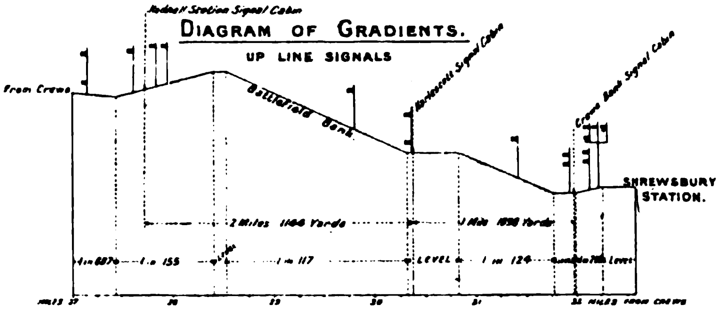


Railway Engineer O.R. 752



Railway Engineer O.R. 752

Fig 4.



Railway Engineer O.R. 752

*The regulator handle was closed, but this may have been due to the fact that the driver had hold of it at the moment of overturning. The man's body was jammed between the regulator handle and the boiler in such a way that the handle had to be taken off before the body could be extricated.

are those during which human vitality is at its lowest point, and the need of sleep is most felt. In the present instance, driver Martin had been out of bed the whole of the previous night, viz., from 8.15 p.m.* on Sunday to 6 a.m. on Monday. He had a long interval of rest at Holyhead, but to what extent he took advantage of this or whether he got any sleep cannot be ascertained. He returned to work at 7.25 p.m. on Monday evening, with the prospect of another night out of bed before him, and it may well have happened that on the fatal run between Crewe and Shrewsbury, *i.e.*, between the hours of 1.22 and 2.8 a.m., he was tired and sleepy. It may be that he was awake when he passed Hadnall, and that he shut off steam when he crossed the summit of the line near the place. But it is believed that, after this, sleep overcame him, and caused him to close his eyes for a few minutes, so that he passed Harlescott Crossing and Crewe Bank without knowing it. He thus failed to see the signals at the latter place (which were at danger), and did not apply the brakes at the usual place, viz., a quarter of a mile outside the Crewe Bank distant signal. Owing to the falling gradient, the speed of the train rapidly increased, and when Martin roused himself (or, perhaps, was roused by the fireman), he was past Crewe Bank signal-box, and close to the junction, the speed by that time being exceedingly high. He then instantly applied his brake with full force, and reversed his engine, but before these measures had time to take effect, the engine had reached the junction, and the end came. In this connection it has to be borne in mind that when a train is travelling at 60 miles an hour, a minute in time is equivalent to one mile in distance, and as such a train could be stopped in about three quarters of a mile, it follows that a delay of less than one minute in the application of the brake makes all the difference between safety and danger.

It may be asked, what was the fireman doing, and why did not he awake his driver? Possibly he too was asleep, though, as he was a younger man, this is not so probable as in Martin's case. A more likely explanation is that he did not know that Martin was asleep. Moreover, when appoaching a place like Shrewsbury, especially after climbing up the ascents between Crewe and Whitchurch, and again between Wem and Hadnall, it would be necessary for him to get his fire in order, fill up the boiler, and perfom other duties connected with finishing the run. These duties would sufficiently occupy his attention, and, as the signals were all on the driver's side of the line, it would not be necessary for Fletcher to look out for them.

Reviewing all the circumstances of the case, the most probable explanation of the accident is as given above.

In America accidents have frequently been found to be due to the engineman or men being asleep, but in England this has rarely, if ever, been recognized as the cause, or as a potential cause, of an accident†

It has now to be considered whether anything can be done to avert such disasters in the future. There has been the usual crop of suggestions, based as a rule on imperfect knowledge, and of little or no practical value. The idea that all "dangerous curves" on our railways should and could be forthwith abolished. But this is clearly impossible.

The presence of a third man on the footplate is undesirable. It would necessarily involve a division of responsibility, which would be bad for discipline, and lead to constant disputes. The extra man would have nothing to do and, besides being very much in the way of the driver and fireman, he would be disposed to enter into conversation, and perhaps argument, with them. Moreover, if his hours were the same as those of the other men, he would be as likely to be overcome by sleepiness or drowsiness as they.

The provision of speed indicators, speed recorders, or "tell-tales," forms the subject of another proposal. Appliances of this nature, whether on the engine or fixed alongside of the railway, would be extremely valuable for the purpose of checking the movements of drivers and of ascertaining the manner in which their time was spent, the speed at which they had been travelling, and the extent to which speed regulations had been observed. The adoption of speed indicators has been made compulsory upon all French railways by the Government, and it would be a good thing if they were more generally in use in this country. But so far as the case now under consideration is concerned, in which the driver was asleep, any such apparatus would be perfectly useless for purposes of safety. Nor would speed boards or additional signals or lights be of any service under these circumstances.

Several writers have drawn attention to the necessity for providing signals on the engines themselves, and these have been for some time attracting the close attention of the Inspecting Officers of the Board of Trade and of Railway Companies. Such an appliance, to be of any service, must be absolutely reliable and should give distinct audible signals by whistle or bell both for "safety" and "danger," inside the cab of the engine. Such signals are usually called for short, "cab signals," and more than one railway company in England is now experimenting with devices of this nature. They require a special apparatus, not only on the track but also upon every engine which is likely to travel over the line upon which they are in use. In addition to these, and working either in conjunction with them or independently of them, it has been proposed to introduce "train stops," whereby the brake is automatically applied should a train pass a "danger" signal. Numerous inventions, both electrical and mechanical, have recently been brought out for operating this "train stop," but, as a general rule, these have been found to be either too complicated or for other reasons totally unfit for railway purposes. An "automatic train stop" without "cab signals" is at the present time in use on some of the underground electric railways of London, and has been found to give good results; but the conditions on these lines, especially as regards speed, are very different from those on our main steam railways, and it has yet to be ascertained whether such an appliance is applicable to steam railways on which the conditions as to speed, weight of trains, and gradients present so many variations. The question of the general adoption of "cab signals" and "automatic train stops" is not yet settled, and is not only receiving consideration in his country, but is also under investigation by the Interstate Commerce Commission of America, a portion of whose report for 1907 is devoted to the subject.

In the meantime it is for consideration whether detonators might not be more extensively employed than at present for the purpose of arousing the attention of a negligent engine driver, should he allow his train to overrun a "danger" signal, or approach a place where, owing to curves or other local conditions, danger is to be apprehended, at too high a speed. Many signal-boxes are at present equipped with an apparatus whereby a signalman can, without leaving his box, place a detonator on the line at or near the home signal whenever this is at danger. But, hitherto, these devices are only brought into operation during times of fog or falling snow. If they were always in use, by day and by night, in clear weather as well as in fog, it would be impossible for drivers to pass a "danger" signal without receiving a reminder of their position. A record could be kept by the signalman of any train which thus exploded a detonator unnecessarily, by which means the driver at fault could be traced, and suitably dealt with.

In connection with this suggestion the position of Crewe Bank signal-box calls for remark. It is only 398 yards, and its home signal 527 yards from the Crewe Junction home signal, which distances, having regard to the gradient (1 in 124) and other local conditions appear to be insufficient, and it should be moved back at least 500 yds., and that pending the introduction of "cab-signals" or "train stops" it should be provided with an apparatus such as that already described, for placing a detonator on the line whenever the home signal is at danger. If this were done, the Crewe Bank home signal could be placed nearly 1,200 yards from the junction at which the derailment occurred, so that in the event of a driver running past the Crewe Bank home signal at danger and being reminded of the fact by the explosion of the detonator, he would have sufficient distance in which to bring his train to a stand before reaching the junction.

When a railway accident occurs, the question usually arises as to whether the brakes of the train have been tested, either at the starting point or at any place where the engine has been changed, or where coaches have been attached or detached. It is, as already stated, the duty of the rear guards to make this test, and whenever they are asked whether they have done so, the answer is always in the affirmative. With no wish to cast any reflection on the general trustworthiness or veracity of guards, it will be admitted that an unsupported statement made by the person responsible for the performance of an important duty cannot be regarded as conclusive, especially in cases where doubts arise whether the brake pipe was properly connected up throughout the length of the train, or where allegations are made that for any reason whatever the brakes were inoperative. Moreover, it is probable, when trains are late and guards are being hustled by the platform staff, that they are not given sufficient time for making the test. The proper testing of the brakes of a train is of such importance that it should be performed, or at least witnessed, by the station-master, or the platform inspector, who should sign a certificate (to be retained by the guard) recording the fact that the test had been made, and stating the degree of vacuum (or air pressure) indicated by the gauge in the guard's van, both before and after the test, and whether the brakes showed any sign of leaking off. If some such record as this were available, many of the doubts as to the condition of the brakes, which now arise after a railway accident, would be eliminated.

The Road Book is a book in which drivers enter the sections of the railway with which they are acquainted as regards signals, gradients, stations, etc., and over which they are competent to take a train. The practice on the L. and N.-W. R. is for every man to sign this book in April and October of each year, and drivers are held not to be acquainted with, and are prohibited from signing for, any section of the line over which they have not travelled in charge of a train during the preceding six months. The signatures in the book referred to have to be witnessed, and for this duty it appears to be the custom to detail a cleaner from the locomotive shed. Signatures witnessed in this way by an inexperienced lad are not of much value, for it must be remembered that he has not only to witness the signatures, but also to catechise the drivers as to whether they have been over the various sections of the road during the previous six months. The signatures should be witnessed by some responsible officer.

The same remarks apply to the entries in the book in which drivers acknowledge the receipt of Rule Books, Working Time-books, and the Appendices to the latter, and other documents.

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*He left Crewe with the 9.22 p.m. train to Manchester, and must have booked on duty about one hour before this.

†Hitherto it has been officially called, by Board of Trade Inspectors, "temporary mental aberration," and Col. Yorke would have saved himself a lot of abuse if he had preserved the old verbose description of "dozing."—[ED. *R. E.*]

EDITOR'S NOTICE.—All manuscripts and communications should be distinctly written, or preferably type-written, on one side of the paper only, and addressed to the Editor **3, Ludgate Circus Buildings, London, E.C.** The Editor cannot undertake to return rejected manuscripts or drawings unless accompanied by a stamped directed envelope.

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THE Railway Engineer

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Contents.

Sir Chas. B. Renshaw, Bart., deputy chairman of the Caledonian R., has been elected chairman in succession to **Sir Jas. King, Bart.,** who has resigned, and who has been a member of the board for 30 years (chairman since 1906). Mr. E. Cox, director, has been elected deputy chairman.

Mr. R. H. Selbie, secretary of the Metropolitan R., has been appointed general manager in succession to **Mr. A. C. Ellis,** who was solicitor to the Company from 1898 to 1901, when he was appointed general manager, and who, though his agreement has not expired, has retired on terms which are mutually satisfactory to himself and the company. **Mr. W. H. Brown,** the audit accountant, has been appointed to succeed Mr. Selbie as secretary.

Mr. S. H. Webber, accountant of the Midland and South-Western Junction R., has been appointed secretary, in succession to **Mr. E. T. Lawrence,** who has, as we have before stated, been appointed secretary of the Barry R.

Mr. D. Wedderburn, deputy locomotive superintendent of the East Indian R., is "acting" locomotive superintendent in place of **Mr. T. R. Browne,** who has gone "on leave" prior to retirement, and **Mr. I. A. McDonnell,** district locomotive superintendent, is "acting" deputy locomotive superintendent.

Mr. Russell Willmott has been appointed traffic manager and engineer of the East and West Junction and Stratford-on-Avon, Towcester and Midland Junction Rs., in succession to **Mr. J. F. Burke,** who has resigned.

Mr. W. Cresswell has been appointed superintendent of New Street Joint Station, Birmingham.

Mr. Richard R. Baskin has been appointed audit accountant of the Great Northern R. of Ireland in succession to **Mr. Wm. Sandow** who has retired on superannuation.

Mr. Dixon Boardman, son of Mr. W. H. Boardman, principal proprietor of the *Railway Gazette,* has been appointed European representative of the Hall Signal Company of America, with offices at Queen Anne's Chambers, Westminster.

We regret to record the death, on the 18th ultimo, at Glasgow, of **Mr. Robert Millar,** general manager of the Caledonian R. He succumbed after an operation for appendicitis. He was born in Stirling in 1850, and entered the goods department of the Caledonian R. as a clerk in 1873. After experience in canvassing he was appointed the company's representative in Ireland. After holding that post for 10 years he returned to Glasgow to take control of the canvassing branch, and conducted a special enquiry into the working of the mineral traffic. Early in 1901 he was appointed superintendent of the Western district, and three weeks later (upon the sudden death of Mr. Patrick) interim manager, and subsequently general manager. He was very popular with the general staff and greatly esteemed by directors, officers, and all who knew him.

We also regret to record the death of **Col. Sir Nigel Kingscote, G.C.V.O., K.C.B.,** Paymaster to the King's Household, and a director of the Great Western R. He died on the 22nd ultimo at Worth Park, Crawley, of syncope. He was in his 79th year. He served in the Crimean War as A.D.C. to Lord Raglan.

*

Notice of Removal.

PINTSCH's Patent Lighting Co., Ltd., inform us that they have considerably enlarged their works at Dover Wharf, Limehouse, E., and have removed their London offices from 38, Leadenhall Street, to Friar's House, New Broad Street, E.C.

*

Automatic Couplings: Prize Competition.

THE National College of Italian Railway Engineers, in order to encourage the study and facilitate practical trials of automatic couplings, have instituted an International Competition, and offer a first prize of 10,000 francs. and a large gold medal, presented by H.M. the King of Italy, and a second prize of 5,000 francs. Competitors must apply for admission, not later than the 31st December, to the Executive Commission, care of *Unione Italiana delle Ferrovie di interesse locale e di Tramvie*, via Nirone, 21, Milan.

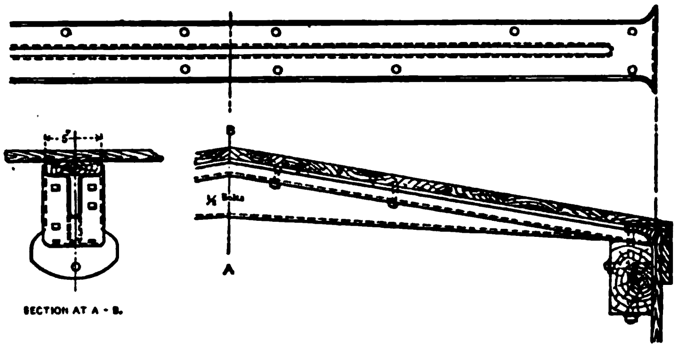
*

Lectures on Railway Subjects.

AT the London School of Economics, Clare Market, W.C., commencing on the 5th inst., a series of evening lectures on railway subjects will begin. Mr. W. Tetley Stephenson, B.A., late of the North Eastern R., will deliver 20 lectures on *Railway Economics—Operating;* 20 upon *Railway Economics—Commercial*, and 20 upon *Economics of Railway Construction and Locomotive Operation.* Mr. H. W. Disney, B.A., will deliver a series of 20 lectures on *The Law of Contract and of Carriage by Railway.*

Pressed-Steel Roof Bars.

One of the most important developments in box-car design and construction has been the introduction of pressed steel car-lines on roof-bars. This type of roof-bar is made in one piece and can be used to replace the wooden ones without any change in the construction of either the car body or the roof. They provide a stronger roof support with a less number, with less weight per car, and in most cases with greater inside clearance than wooden ones do. The Cleveland Car Specialty Co. has designed the new pattern illustrated, especially adapted for the outside metal roof, and in which a channel section is reinforced by a U-section pressed into the web of the channel. The channel section, with a 5in. nailing



strip bolted to it, gives a wide support for the longitudinal course of boards and the additional strength due to the U-section makes it stronger with less weight than any possible combination of wood and iron, or any commercial shape that may be used. The importance of adding strength to freight cars without increasing their weight is generally recognised. Tests and experiments show, says *The American Engineer and Railroad Journal*, that in practically all cases a pressed steel shape will give better results in this respect than commercial shapes, as additional strength may readily be provided where it is required. This is especially true of compound shapes, which must be built up and bolted or riveted together.

*

American Through Rates.

It is currently reported, according to *The Railway and Engineering Review* (Chicago), that, as a result of the Interstate Commerce Commission requiring the publication of the inland proportion of foreign rates, transcontinental railroads have determined to practically withdraw from Asiatic business. This action fulfils the threat made by the railroad officials at hearings before the Commission that they would be forced to this step unless that body rescinded its order. According to the preliminary announcement, the present through tariffs from points in this country to Asiatic ports, Australia, and New Zealand, by way of the Pacific Ocean, will expire October 31. On import traffic the present through rates will be continued on such articles as firecrackers, paper fans, matting and tea. After October 31 the only rates in effect by the Pacific route will be the combination of the local railroad rate to the coast and the local steamship rate.

*

Brukner's Reinforced Concrete Sleepers.

Owing to the increasing scarcity of hard wood suitable for sleepers considerable attention is being given on the Continent to reinforced concrete sleepers, large numbers of which are being laid down.

Several samples of one of these sleepers have just recently arrived at the Hungarian Exhibition, Earl's Court, and are on view in the Queen's Palace. The patentee of this sleeper is Mr. Maurice Brukner, of Budapest. The salient features claimed for it are the mechanically accurate arrangement of the re-inforcing rods and wires which are placed near the upper and lower surfaces. Creosoted hardwood blocks, tapered upwards, are insetted under the rail or chair seat to take the fastenings, and these are supported on the underside in stirrups attached to the re-inforcing bars, so that it is claimed that spikes may be used in place of screws or bolts if desired. These sleepers weigh about 270 to 290 lbs., and will sustain a pressure of 75 to 80 tons.

*

Acetylene Flare Lights.

The Wakefield Patent Acetylene Flare Lights, of which we published an illustrated description in our issue for last March, were used with great success in the recent motor race for the Grand Prix at Dieppe and again at the Stadium at the Franco-British Exhibition during the night for the 24-hours' walking race. The light used gave a flame capable of adjustment of from 500 to 5,000 c.p., the light being pure, soft, and entirely free from smoke or smell. The great value of these lights lies in the fact that they are constructed to produce and effectually control acetylene gas, which has 15 times the illuminating power of coal gas. They are also quite portable and require no attention while working, their flame reaches its full power in three minutes, is maintained steadily until the charge of carbide is exhausted and is not affected by wind or rain. By means of large reflectors and swivel joints the light can be focussed in any direction without moving the lamp or can be spread over an area of 300 square yards. They are therefore especially suitable for lighting permanent way and bridge alterations or repairs, breakdowns, tunnel work, and any constructional work carried out at night.

*

On the Lighting of Workshops.

To furnish the most up-to-date machinery and tools, and pay the present high prices for labour, and then to handicap the workmen by insufficient or improperly placed lights, is a fallacy too patent to require argument; and still such cases are by no means uncommon. It will perhaps add to the impressiveness of this statement to make use of a few computations. Let us take as a basis the electric light, which is admittedly the most expensive form of artificial illumination, and let us say that the current is purchased at the retail price of 10 cents (5*d.*) per unit (kilowatt hour). A 16-c-p lamp can be burned 18 hours by the use of one unit, that is, at a cost of 10 cents (5*d.*), or 55 mills (·277*d.*) per hour. The ordinary workman, receiving, say, 20 cents (10*d.*) per hour, would only have to lose a little over 1½ minutes out of an hour to represent a loss equal to the cost of the light; while a skilled workman, receiving, say, 50 cents (2*s.* 1*d.*) per hour, would have to lose only a little over ½ minute every hour to represent a similar loss. In other words, the ordinary workman losing 13 minutes in a day of 8 hours, or the skilled workman 5 minutes in the same time, would equal the cost of running the lamp for the entire working day. But instead of electricity costing 10 cents (5*d.*) per unit, it may be generated in large works, where power is already at hand, as well as the fixed charges of superintendence, etc., as low as 2 cents (1*d.*) per unit, which would reduce the above figures to one-fifth; that is, the average workman would have to lose only about 2½ minutes in an entire working day of 8 hours, and the skilled workman but a little over a minute, to represent the cost of the lamp for a day. But the loss in wages is not all; loss in time of the operative represents a loss from the non-use of the machine. And again, besides there being a reduction in the amount of product, there is often a reduction in quality also, which is far more serious than the reduction in quantity. —*The Illuminating Engineer.*

Electric Train Lighting.

AFTER a lengthy trial with the "Tudor" system of electric train lighting the North British R. Co. has, we understand, given the Tudor Accumulator Co. a repeat order for the dynamos and other apparatus to equip ten more coaches with the system.

*

Proposed Light Railways.

THE Board of Trade has recently confirmed an Order authorising the construction of a light railway from Llandilo to Lampeter, in Wales. Also an Order amending the previous Order, authorising the construction of the Central Essex light railway and extending the time allowed for its construction. Also an Order authorising the construction of light railways in the Urban District of Watford, and amending the County of Hertford Light Railways (No. 1) Order, 1904. Also an Order conferring additional powers on the Tanat Valley Light Railway Co.

*

Estimates of Coal Supply in Pennsylvania.

THE United States Geological Survey estimates, says the *Railway and Engineering Review* (Chicago), that the coal originally in the Pennsylvania anthracite fields aggregated 21,000,000,000 short tons and in the bituminous fields 112,674,000,000 short tons, leaving still in the ground 17,000,000,000 short tons of anthracite and about 110,000,000,000 of bituminous. It is thought that at the rate of production reached in 1907 the available coal supply in Pennsylvania should last about 490 years.

High Speeds on the Baden State Railways.

IN the mountainous country of South Germany high railway speeds are much more difficult to obtain than on the level plain of North Germany, especially Prussia. And the number of splendidly equipped passenger trains which are operated every day over the main line of the Baden State Rs. between the commercial metropolis of South Germany, Mannheim, and Bâle (Switzerland), by way of Karlsruhe-Freiburg, is remarkable.

On the line Karlsruhe-Offenburg (45 miles long) over which run the express trains of the great European trunk line, Paris-Vienna-Constantinople and Milan-Gothard-Berlin, there are, according to the official time table, every dav 26 up and 26 down fast trains, and 19 up and 17 down local trains. On the whole main line, Mannheim-Heidelberg-Karlsruhe-Baden Baden-Bâle (about 16 miles long) there are 12 up and 13 down fast trains and 7 up and 7 down local trains. During the summer season several of these trains are in two or more sections.

Line.	Distance miles.	Train No.	Time min.	Avg. Spd. m.p.h.
Freiburg-Offenburg ...	39·9	109 d*	43	55·0
,, -Oos (Baden-Baden)	64·4	85 d	71	54·4
Mannheim-Karlsruhe ...	37·9	86 d	43	52·9
Karlsruhe-Mannheim ...	37·9	85 d	43	52·9
Freiburg-Offenburg ...	39·4	9	45	52·5
Freiburg-Offenburg ...	39·4	109 d	45	52·5
Freiburg-Lahr	28·0	7	32	52·5
Karlsruhe-Freiburg ...	83·4	86 d	96	52·1
Freiburg-Lahr	28·0	77 d	33	50·9
Freiburg-Lahr	28·0	21	33	50·9
Freiburg-Lahr	28·0	42	33	50·9
Freiburg-Offenburg ...	39·4	1 d	47	50·3
Oos (Baden Baden)-Karlsruhe	20·1	85 d	24	50·3

* d signifies: Corridor train.

The new *Eisenbahn-Bau-und-Betriebsordnung* for the German railways, dated November 4, 1904, permits a speed of 62½ miles an hour, 100 *Kilometer in der Stunde*, which speeds, however, are often surpassed, particularly when the trains are late. Since May, 1904, when trials were made with a new "Atlantic" (4-4-2) engine, that type, built in the locomotive works at Karlsruhe and Munich, has been used to haul all big Baden express trains. On the trial runs in May, 1904, the 39·4 miles between Offenburg and Freiburg, whi h has gradients of 1 in 171, were covered in 32½ minutes, with an average speed of 72½ miles (116 kilom.) and a maximum speed of 90 miles (144 kilom.) an hour.

The ordinary train speeds are, of course, not so high. The Holland Limited makes the 39·4 miles between Freiburg and Offenburg in 43 minutes, *i.e.*, an average speed of 55 miles an hour. But on account of the difficulties at the custom at Bale the train is often—particularly during summer months —late, and then the run is made in 40 minutes, or at an average speed of about 60 miles per hour.

The fastest trains of the Baden State R. which run at more than 50 miles an hour are:—

Especially remarkable is the run of train No. 86 d between Karlsruhe and Freiburg. For in the last 30 miles there is a total rise of about 740ft. Over these rising gradients an average speed of 50 miles and more is impossible, as the engine has then already run more than 100 miles (it hauls the train from Mannheim); besides which the train is a rather heavy one. As the rise does not begin before the second half of the line Karlsruhe-Freiburg, the train has to run very fast before this, and important stations like Appenweier (junction line for Strassburg) are daily passed by this train, in spite of points and crossings, at an average speed of about 60 miles an hour.

Train 85 d lately made the trip Freiburg-Oos (Baden Baden), 64·4 miles long, in 65½ minutes, or an average speed of 59 m. an hour, and on another occasion in 64½ minutes instead of 71, as per time table, or at a speed of 60 miles an hour. At times the train had more than 70 miles' speed, for it made the 5·35 miles between Friesenheim and Schutterwald in 4¾ minutes, a speed of 67·6 miles (108·13 *kiloms.*). The two miles (nearly) between Ringsheim and Orschweier were made in 1¾ mins., or at an average speed of 70·7 miles (113·04 *kiloms.*). Such examples could be greatly multiplied.

Finally the following table may show a number of remarkable runs which I made with trains during summer 1907. They were all ordinary runs, and the high speed was only caused by the trains being late.

Line.	Distance miles.	Train No.	Time min.	Avg. Spd. m p.h.
Freiburg-Oos (Baden B.) ...	64·4	85 d	64½	59·9
,, ,, ,, ...	64·4	85 d	65½	59·0
Offenburg-Karlsruhe ...	45·1	109 d	47½	57·0
Freiburg-Lahr	28·0	77	29½	56·9
Freiburg-Offenburg	39·4	1 d	41½	56·8
Freiburg-Lahr	28·0	77	30	56·0
Freiburg-Oos (Baden B.) ...	64·4	85 d	68¾	56·4
Appenweier-Oos (Baden B.)	20·1	21	21½	56·0
Offenburg-Karlsruhe ...	45·1	109 d	49	55·2
Karlsruhe-Mannheim ...	37·9	85 d	42½	53·5

All these speeds bear evidence of the excellent rolling stock and permanent way, particularly the locomotives, of the Baden State Rs. In view of the frequency of the passenger and goods trains on the Baden trunk line—Mannheim-Bale—these extraordinary high speeds are very remarkable, and they are not surpassed in Germany.

ALBERT KUNTZEMÜLLER, Ph.D.

Books, Papers and Pamphlets.

Handbook of Railway Surveying. By B. STEWART. E. and F. N. Spon, London and New York.

To any young railway engineer who is only just beginning his work in the field this book should be of much value, and it may be of use, also, to older engineers who are not always able to remember first principles and early teaching.

The book is not of large size, but it deals in a very able manner with its subject. It is surprising what an amount of information can be given in such a small compass, but nevertheless we have here the full practice of surveying laid down in such a way that given the various instruments in proper adjustment to begin with, the learner can at once proceed to use them both to chain his survey, overcome obstacles and rivers, to level his ground and inaccessible heights, and more than this, to set out his curves, cuttings and embankments by

the theodolite, optical square and box sextant, the use of each instrument being sufficiently described.

Of course, in actual work many difficulties arise which only personal experience and ingenuity can overcome, but even with the more comprehensive text-books the same thing will inevitably occur.

One point in the little book deserves emphasis, that is, the student should always remember that field books should be kept in such a way that another person who has not been out on the survey can easily understand them and plot from them if necessary. This is a point not often observed by young engineers, and the lack of care frequently brings anxiety when the plotting is to be done, and trouble if the field book has to be referred to some length of time later.

One statement made, that the American system of laying down wrought iron rails on timber and fastening them with spikes " is one of the chief causes of the frightful railway accidents which almost daily occur there," sounds rather startling, and may be regarded as exaggerated writing.

*

Tables for Setting Out Curves. By H. WILLIAMSON. E. and F. N. Spon, London and New York.

This is a neat little book of pocket size, giving an explanation of, and tables for, the setting out of curves, based on the metrical system, and will be extremely useful to many young English engineers who have to set out railways in countries where the metric system is in vogue.

The tables are made available for both the "tangential angle" system of setting out and also for the alternative method, by means of "offsets from tangent lines," and are prepared for set radii varying by 50 metres for curves between 200 to 1,000 metres, and by 100 metres for curves of greater radius.

It occurs to us that more use could have been made of the book if tables for intermediate curves had also been given, since the engineer has far more frequently to make curves to suit the tangents than he is able to choose arbitrarily a radius of round figures.

Practical hints of value are given as regards the use of the theodolite, but it would not have made the book much larger if an explanation of the basal formula $1718{\cdot}9 \div R$ had been offered.

The transitional curve is not dealt with in any way, but, of course it would be a difficult matter to provide tables for such curves, although for easement they are essential both for railways and canals.

It is a pity that a similar small work with tables on the usual English base of the 66ft. or 100ft. chain is not published.

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Economics of Railway Operation. By M. L. BYERS, C.E. London: Archibald Constable & Co., Ltd.

Though the Author of this great work is the chief engineer for maintenance of way of the Missouri Pacific R., which is 6,000 miles long, it is not mainly devoted to engineering subjects, as each department of railway "operation" is dealt with.

The work is divided into seven parts, but really six of these "parts" are "chapters," and deal with organisation: employment, education and discipline of forces: accounts: reports: analysis of operations and control of expenses: betterments. They occupy over 300 pages: the remaining 360 pages of matter form part V. under the heading "economic operation." This is sub-divided into six chapters, in which each department—maintenance of way and structures: machinery: transportation: traffic—are reviewed.

Under the subject of accounts we like the idea advanced by the Author that earnings should be sub-divided beyond what is done in the ordinary arrangement of accounts, not for publication but, as suggested by Mr. Byers, as a memorandum. He divides these earnings into six main heads—the products of (1) agriculture, (2) animals, (3) manufacture, (4) forest, (5) mines, (6) miscellaneous—and these are sub-divided into a total of 59 entries. The expenditure of operation he divides into five heads:—(1) Maintenance of Way and Structures, (2) Maintenance of Equipment, (3) Traffic, (4) Conducting Transportation, (5) General expenses. Here, again, the Author suggests "memorandum accounts." He recommends that details should be kept of the cost of (*a*) handling rails, (*b*) handling ties, (*c*) handling ballast, (*d*) ditching, (*e*) other work. The motive power department might keep the cost of (*a*) supervision and inspection, to include the pay of all foremen and inspectors, with their clerks and messengers, except such as are charged to "Superintendence; (*b*) undistributed labour, to include pay for all mechanics and labourers whose time is distributed to shop output, such as men employed in cleaning shop grounds, yards and tracks of scrap material; (*c*) switching service; (*d*) fuel for boilers, forges, etc.; (*e*) small hand tools; (*f*) sundries, such as cutting up condemned equipment, testing air-brakes, horses and horse-keep, royalties, patent rights, etc. Another memorandum account should be for the cost of repairs through accidents to (*a*) locomotives, (*b*) passenger stock, (*c*) freight stock, (*d*) track.

In the second chapter of the part dealing with economic operation are given details of the expenditure in the Maintenance of Way Department of a railway in one of the Eastern States for the year 1904, which is worth noting. The line was 4,000 miles in length, and the cost of maintenance was $6,900,250. The details are given under 21 heads with 52 sub-heads. Mr. Byers recommends that a programme should b drawn up in the fall of each year of all repairs to structures that are intended during the following year. Each work proposed is divided into different heads, the first four of which are (1) to prevent accident to person or property, (2) to prevent deterioration of property, (3) to increase company's facilities, (4) to improve appearances. This list is gone through, an inspection is made by the Engineer of Bridges and Buildings, unnecessary work cut out, other schemes modified, and eventually a programme for each Divisional Engineer is sanctioned on a special form—copy of which is given—proportioned out for six months. On this is marked the amount authorised for each month and the total from the commencement of the half-year to the end of that month, and the engineer fills in the amounts actually expended. As the form is printed on transparent paper a blue-print can be made therefrom, and this is sent to the Chief Engineer.

We would that Mr. Byers had given us more information as to other kinds of sleepers than wooden ones. He dismisses steel sleepers in eleven lines and re-inforced concrete in four lines. But as a rule each subject is well considered.

The next chapter deals with Machinery Department Operations. It opens with some debatable remarks. "The locomotives and cars must be regarded as Transportation units, rather than from the point of view of the mechanical expert. . . . . It may considerably increase the cost of locomotive repairs per mile run if a locomotive, not in perfect condition, is allowed to make an additional trip before repairs are made; yet the saving in the total amount of time the locomotive is out of service and the consequent increase in its earning power may justify a considerable increase in the unit cost of repairs." Further on we read "The degree of economy secured in the Maintenance of Equipment is dependent upon (*a*) accurate determination of *what* repairs should be made (*b*) modern shop facilities of adequate capacity, (*c*) shop economies." The Author divides the latter as follows:—(1) Thorough organisation of forces, avoiding unnecessarily high percentage of skilled labour, (2) thorough and competent supervision, (3) the laying out and handling of work so that no delays from shortage of material and no unnecessary moving of material shall occur, (4) the balancing of forces in different departments, (5) the use of materials graded in quality to exactly fit the purpose for which they are intended, (6) the running of machine tools at economic speed, (7) scientifically conducted investigations to determine the proper relations of the fundamental dimensions of the machine, car or engine. He then says that beyond this the cost of the maintenance of engines depends largely upon the following fifteen factors. We will only quote three of these: (5) Avoidance

of the constant revision of standards and the scrapping of partly-worn parts in order to introduce new and scarcely more efficiently designed parts; (9) use of an adequate means of fixing responsibility for engine failures and excessive repair costs among the four factors in the situation, viz.:— (*a*) the engineman, (*b*) the shop making the running repairs, (*c*) the shop making the general repairs, and (*d*) the local conditions; (10) proper records and system of analysis, so that the data usually obtained shall be available for the study of causes and effects.

Space forbids our referring to the concluding portions of the book. We can only say that whilst it is written by an officer of a big concern and deals with matters as they are regulated on large lines, yet it is a book that will amply repay the officer—engineer, motive power or transportation—of any line, large or small, for perusal.

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Books Received.

Power Railway Signalling. By H. Raynar Wilson, author of "Mechanical Railway Signalling." With 623 illustrations. London: The Publishers of The Railway Engineer, 3, Ludgate Circus Buildings, E.C. [342 pp.; 12 by 9⅝; price, 18s. net.]

Economics of Railway Operation. By M. L. Byers, C.E. Chief Engineer Maintenance of Way, Missouri Pacific R. Illustrated. New York: "The Engineering News" Publishing Co.; London: Archibald Constable and Co., Ltd., 10, Orange Street, Leicester Square, W.C. 1908. [672 pp.; 9⅛ by 6¼; price, 21s. net.]

The Railroad Signal Dictionary: an illustrated vocabulary of terms which designate American railroad signals, their parts, attachments, and details of construction, with description of methods of operation and some illustrations of British signals and practice. With 3,127 illustrations. Compiled for the Railway Signal Association by Braman B. Adams and Rodney Hitt under the supervision of the following committee: C. C. Anthony, assistant signal engineer, Pennsylvania RR., Azel Ames, Junr., signal engineer, electric zone, New York Central and H.R.RR., and J. C. Mock, electrical engineer, Detroit River Tunnel Co. 1908. New York: "Railway Age Gazette," 83, Fulton Street; London: "The Railway Gazette," Queen Anne's Chambers, Westminster, S.W. [472 pp.; 11½ by 8¼; price, 29s. net.]

Notes on Locomotives.

In a special article which appeared in our June issue on French compound tank engines we described some recent examples of this class of locomotive, namely, the 4-6-0, 4-8-0 and 4-6-4 types. Since then, however, another design has been brought out and put in service on the suburban lines of the Western Railway of France.

These engines have six coupled wheels and a radial bogie at each end. This 2-6-2 wheel arrangement is not novel on French lines, as the Eastern R. built a series of this type a few years ago, but the new engines differ not only in dimensions, but have four compound cylinders, whereas their predecessors have two simple cylinders. Another feature of interest lies in the position of the cylinders, the centres of which are all in the same transverse plane, and drive the same axle. In these points they differ from the bulk of French 6-coupled compound engines: the H.P. cylinders are inside, the L.P. outside the frames, all four cylinders have separate valves and gears, the H.P. valves are of the piston form, the L.P. balanced flat valves. The boiler is of the Belpaire type.

The principal dimensions are:

Cylinders h.p., 13⅜in. by 24in., l.p., 21in. by 24in.; wheels, coupled, 5ft. 2in.; bogie, 3ft. 2½in.; wheelbox, total, 29ft. 4in.; boiler, pressure, 228lbs.

Heating surface, tubes, 1,791 sq. ft.; firebox, 135·5 sq. ft.; total, 1,926·5 sq. ft.

Grate area, 27 sq. ft.; weight full, adhesion, 50 tons; total, 74 tons.

Although, as mentioned in our last month's issue, the "Atlantic," or 4-4-2 type of locomotive continues to retain a considerable amount of favour among Continental engineers, yet there can be no doubt but that six wheels coupled engines are the predominating type: this is mainly the outcome of the very light permanent way common to the majority of the lines, a fact which limits the permissible axle load to about 17 tons, while 14 tons is even more common, hence to obtain the requisite adhesion weight six coupled wheels have to be resorted to.

Among the latest examples of the above-mentioned types are the new standard engines, for heavy passenger service, of the Prussian State Railways; it is perhaps hardly necessary to say that they are simple expansion engines, fitted with the Schmidt system of high-superheating. A somewhat similar design has also been adopted for the Austro-Hungarian State Railways, and these engines also have superheaters. Both designs embody round topped boilers, pressed to a working pressure of 170 lbs.; the superheating tubes are contained in three rows of fire tubes. The cylinders in both classes are outsde the frames and drive the middle coupled axle. The valve motions are of the Walschaerts type, actuating piston valves. A comparison of these engines is given in the annexed table of dimensions:

	Prussian.	Austro-Hungarian.
Cylinders	23·2in. x 24·8in.	21·65in. x 25·59in.
Wheels, coupled	5ft. 8·9in.	5ft. 11·6in.
Wheels, bogie	3ft. 3·3in.	3ft. 4·3in.
Wheelbase, rigid	15ft. 0·3in.	13ft. 9·3in.
Wheelbase, total	27ft. 4·7in.	27ft. 2·7in.
Boiler, barrel max. diam., outs.	5ft. 4·2in.	5ft. 1in.
Boiler, barrel length	15ft. 5in.	14ft. 11·17in.
Boiler, firebox length outs. ...	9ft. 2·2in.	10ft. 1·4in.
Pressure	170lbs.	170lbs.
Heating surface, tubes ...	1,463 sq. ft.	1,073 sq. ft.
Heating surface, superheater tubes	531 sq. ft.	465 sq. ft.
Heating surface, firebox ...	158 sq. ft	150 sq. ft.
Heating surface, total ...	2,152 sq. ft.	1,688 sq. ft.
Grate area	28 sq. ft.	33·3 sq. ft.
Weight full, total	68·9 tons	59·5 tons
Weight full, adhesion ...	46·9 tons	39·4 tons

The system of superheating the steam continues to extend, not only in Germany, but in other countries; for instance, besides the tank engines on the Brighton R., there are several 6-coupled goods engines so fitted at work on the Lancashire and Yorkshire R., also the Great Central and Great Northern Companies are about to experiment with the Schmidt superheater. All these engines have simple expansion cylinders, but in several countries compound engines are equipped, the latest example being a new series of 4-cylinder 6-coupled engines on the Eastern R. of France, these being the first high-superheated engines in that country.

An interesting experiment is also being made on the same railway with a system of low superheat or steam dryer on some 4-cylinder compounds; the dryer, which consists of a series of large tubes in the smoke-box, forms the receiver between the H.P. and L.P. cylinders. Of course, but a few degrees of superheat will be obtained from this apparatus, but the results should prove instructive. A somewhat similar (but not so elaborate) arrangement is fitted to the "Pacific," or 4-6-2 engines of the Western R. of France. The Northern R. of France, during the last two or three years, has not introduced any new design, but has continued to build the excellent series designed by M. du Bousquet for the various classes of traffic. Recently, however, a new class of mixed traffic engine has been brought out, the chief point of which is the greatly increased boiler power. The engines embody the usual features of the de Glehn-du Bousquet compounds, having two outside H.P. cylinders driving the middle coupled axle, and two L.P. connected to the crank axle of the leading wheels. Four sets of Walschaerts gear actuate the valves, all of which are balanced slides. The H.P. cylinders are 14 in. diam., and the L.P. 22 in. diam, with a stroke of 25·5 in. The coupled wheels are 5 ft. 8·7 in. diam. The boiler is of the Belpaire type, carrying a pressure of 227 lbs., the heating surface is of tubes 2,298 sq. ft., fire-box, 169·5 sq. ft., total, 2,467·5 sq. ft.; the grate area is 30 sq. ft. In working order the total weight is 67·5 tons, the adhesion weight being 48 tons.

The Great Northern R. of Ireland is putting into service a new type of tank engine, having six coupled wheels and a trailing bogie. We hope to deal more fully with these engines in a future issue.

Train Dispatching by Telephone.

So many disastrous collisions have arisen in America from train-orders being misread or forgotten or getting mislaid, incorrectly sent or received that prejudice not only prevails, but the system of Train Dispatching is regarded as unsafe.

It is not our intention to suggest that the Train Dispatcher should be introduced into this country for controlling the movements on single lines, but for assisting in the running of trains on double lines.

The American system provides a dispatcher for a district who is in telegraphic communication with every point in his district on a wire reserved entirely for train dispatching purposes. He is advised of every train that enters on to the running lines in his district. He is made acquainted with the locomotive number, the driver and conductor. He knows how many cars there are on the train and the loading and what stops have to be made and what traffic is to be dropped and the prevailing state of the weather. Every regular train runs to its schedule, but if this has to be altered "train-orders" are sent by the dispatcher, which orders are worked to unless or until modified. Each special train works to orders. The departure of each train is signalled by the operator to the train-dispatcher and before a train arrives at a station the dispatcher sends word whether he has any orders for the train.

It is the practice in this country for a signalman to act on his own initiative as to whether or not he shall shunt a train for a faster one to pass, and often, if not generally, the train is shunted earlier than needs be, causing it to be longer on the road. The employment of the Train Dispatcher would change all this. He would be acquainted with the abilities of each engine and its driver, and, knowing the running, the load, the gradient and the weather, would be able to judge when the slower train should shunt for the faster. His services would be of great benefit at junction stations in advising the station authorities as to the probable time at which trains that were late would arrive and he would know what extra coaches were on the train. Further, he would not only be the nerves, but the master mind of the district. Knowing all the conditions he can anticipate and foresee the sequel of any movement.

During the spring and summer of 1907 all the mineral carrying lines were blocked with traffic. One of the worst sufferers was the Midland, but we are satisfied that had a train-dispatcher been stationed at, say, Cudworth and in telephonic communication with every signal box between Masborough and Leeds he would have got the traffic over the line. He would have known where every train was and how loaded, with its engine capacity and driver. He would know the available accommodation at every station and siding, what traffic there was in those stations and what was waiting there for dispatch. He would, too, be most useful in arranging the relief for enginemen and guards and making the most of the men available. Without doubt, many of the blocks of traffic that occur from time to time on British railways would not occur were the train movements controlled by a train dispatcher, provided always the man had absolute control.

This leads up to the observations that a change is being made in America in the method of communication between operators and the train dispatcher. All orders to operators and acknowledgments have been made over the exclusive telegraph wire already referred to, but this is now being replaced by the telephone. The first company to do this was the New York Central RR., who, in October, 1907, replaced dispatching by telegraph by dispatching by telephone on the 40 miles between Albany and Fonda. The Chicago, Burlington and Quincy began in December last on a portion of their main line 46 miles long with 11 offices in the circuit. This was so successful that in January another length, of 125 miles and 16 offices, was opened, and in March another, of 28 miles and 15 offices. These were all on double lines, but a fortnight or so later a circuit, 106 miles in length and with 23 offices was opened on a single line.

With a view to having the installation as perfect as possible two 210 pound copper wires have been run at a cost of, approximately, $100 per mile and the equipment is about $50 per station. It is found that operators respond more quickly than with the telegraph, and as they are called up by a loud sounding four inch bell they will often report trains before the dispatcher's call is received in order to save the annoyance. The telephone is more flexible than the telegraph, and the dispatcher can, if necessary, speak to the trainmen personally. One reason for the substitution was the difficulty in getting telegraphists and another was the Federal law limiting their hours of duty to nine per day. But a telephone operator is soon found and further it finds work for servants who have been injured.

The nuisance and delays that arrive from all the bells on a circuit ringing together when a call is made is avoided by the use of a "selective" system. The train dispatcher can ring up any office or, in case of a general call, can ring up all together. One such system is the Morse Code Signal Co., of Milwaukee, who, by the dots and dashes of the Morse code, selects the desired office by the withdrawal of wards similar to those in a Yale lock. Each of these "locks" is cut differently to correspond with a code of dots and dashes, *i.e.*, short and long impulses. The desired office is reached, as its lock is withdrawn by the short and long beats releasing a lever and so opening a whistle or bell.

Another system is the Blake Signal of Boston, Mass. In this there are pendulums, the stroke of which vary at each office and in the train dispatcher's room is a number of pendulums to correspond. These also vary in length accordingly. When he wishes to get an office he inserts a plug in the hole that applies to the desired office. This sets up a current that causes that particular pendulum in his office to pulsate, also every one at the outside offices. The pulsations of these differ according to the length of the pendulum, but one amongst them has the came stroke as that swinging in the dispatcher's office, and in less than a minute these synchronise in their stroke and immediately complete a circuit that calls the operator.*

Yet another system is the Stromberg-Carlson, which by the train dispatcher placing a plug in one of several holes in a controlling device and switching on a battery, joins up the desired office. When the operator answers the call, this is recorded on a tape.

*These two systems are more fully described in "Power Railway Signalling," by H. Raynar Wilson.—(Ed. *R.E.*)

Roofs—X.*

Compression Members—(continued).

Rankine introduced an important modification in the column formula in that the proportion $\frac{l^2}{r^2}$ instead of $\frac{l^2}{d^2}$, or in other words, the square of the radius of gyration instead of the square of the least diameter of the column is used in the formula. The Rankine modification of the Gordon formula was for the purpose of doing away with the double calculation—first of the long, then the modification for the short column—in fact, for the convenience of having one formula for all lengths. There is also the important modification that it is not necessary to distinguish between the different forms of cross section, whether rectangular, angle, tee, or cruciform.

The formula now becomes—

$$p = f \div \left(1 + C\frac{l^2}{r^2}\right)$$

for all forms of cross section except hollow round, in which case d is used instead of r.

When p = ultimate stress per square inch,
l = length of the column,
r = least radius of gyration of the cross section,
f and c = co-efficients whose values depend upon the nature of the material and the condition of the fixing of the ends of the column.

The value of the end condition of the column is c for ends fixed, $4 \div c$ for both ends rounded or pointed, and $16 \div 9c$ for columns with one end fixed and one end jointed.

The values of the other constants are

	f	c
For cast iron,	80,000 lbs. per sq. in.	1 ÷ 3,200
For wrought iron,	36,000 lbs. per sq. in.	1 ÷ 3,600
For dry timber	7,200 lbs. per sq. in.	1 ÷ 2,000

and as below for all ratios of $l^2 \div r^2$ greater than 20 and less than 200.

For mild steel, 48,000 lbs. per sq. in. 1 ÷ 30,000 } (Fidler)
For hard steel, 70,000 lbs. per sq. in. 1 ÷ 20,000 }

Merriman gives the following for timber—

c = 1 ÷ 3,000 both ends fixed.
c = 1·78 ÷ 3,000 fixed and round.
c = 4 ÷ 3,000 both ends round
and f = 8,000

and suggests that struts in roof trusses should be considered as intermediate in condition between flat and round ends, so that the friction 1 ÷ 3000 used in Rankine's formula for the allowable unit stress for flat ends,

$$1{,}100 \div 1 + \frac{1}{3{,}000}\frac{l^2}{r^2}$$

should be replaced by 1·78 ÷ 3,000.

The Cambria Steel Co. and the Carnegie Steel Co. give the following for mild steel—

	f	c
Square bearings	50,000	1 ÷ 36,000
Pin and square bearing	,,	1 ÷ 24,000
Pin bearings	,,	1 ÷ 18,000

The Glengarnock Steel and Iron Co. suggest the following for material at 24 tons crushing strength—

f = 24 tons (53,760 lbs.)

c = 1 ÷ 10,000 for free ends.
1 ÷ 20,000 for fixed ends.

and if a varying factor of safety is required, the following formula—

Factor of safety = $4 + (\cdot05\, l \div d)$
When l = length in inches,
d = least diameter in inches

Merriman and Jacoby give the following for use in the Rankine-Gordon formula—

f = for main lines, 7,500 if iron, 9,000 if steel lateral struts, 10,000 in iron.
and for c = 1 ÷ 40,000 for members with two fixed ends,
1 ÷ 30,000 for members with one fixed, one pin end.
1 ÷ 20,000 for members with two pin ends,

and suggest that for flanges of beams the formula should be used with

l = length of flange in inches between the supports,
r = width of flange in inches,
c = 1 ÷ 5,000
f = for rolled beams used as stringers, 7,500
,, floor beams and riveted stringers over 20 ft. long, 7,500
,, riveted stringers under 20 ft. long, 7,000

Du Bois suggests the following for rectangular struts of wood, using d = least diameter instead of r = radius of gyration.

f = 5,600
c = 1 ÷ 550 for flat ends
1 ÷ 275 both ends pinned
1 ÷ 750 one end flat and one end pinned.

The factor of safety to be 6 + 0·1d for intermittent loading
6 for quiescent loading

Johnson's straight line formula (1886) is—

$$p = \frac{P}{A} = f\left\{1 - \frac{2\sqrt{f}}{3n\sqrt{3E}}\,\frac{l}{r}\right\}$$

which holds good for any value of $\frac{l}{r}$ so long as

$$\frac{l}{r} < n\sqrt{\frac{3E}{f}}$$

but beyond this limit the formula of Euler is to be used.

$$p = P \div A = \frac{n^2 E r^2}{l^2} \quad n^2 E r^2 \div l^2$$

Where $p = P \div A$ = crippling unit stress
P = crippling load
A = area of cross section
f = elastic limit unit stress
E = coefficient of elasticity
L = length
r = least radius of gyration
n is a coefficient depending upon the condition of the fixing of the ends, and is

π for round ends
$\pi\sqrt{(5 \div 3)}$,, hinged ,,
$5\pi \div 2\sqrt{3}$,, one pin one flat
$\pi\sqrt{(5 \div 2)}$,, flat ends

but this formula may be replaced for convenience by the simplified form,

$$p = P \div A = f - (k\, l \div r)$$

where k is a constant whose value is

$$k = \frac{f}{\ }\sqrt{\frac{4f}{3m\pi E}}$$

where m is 1 : 2¼ : or 4 depending on the condition of the ends.

*The previous articles of this series appeared in the *Railway Engineer* as follows:—I., May, 1907; II., July, 1907; III., September, 1907; IV., October, 1907; V., December, 1907; VI., February, 1908; VII., April, 1908; VIII., June, 1908; IX., September, 1908.

C

The straight line formula is not a rational formula by any means, but is assumed merely as a good representation of the results of a series of experiments, the value of k in the preceding equation being deduced by making the straight line tangential to the curve which represents Euler's formula. The straight line formula is founded solely on the reason that a straight line can be drawn to practically coincide with the results of experiments for ratios of l to r between 90 and 150, and as it gives less values than experiments warrant above this point, the error is on the side of safety.

For the values of f, k, and $\frac{l}{r}$ we have

For f = wrought iron, 42,000 lbs. per sq. in.
mild steel, 52,500 lbs. per sq. in.
cast iron, 80,000 lbs. per sq. in.
oak, 5,400 lbs. per sq. in.

For k

	wrgt. iron	mild steel	cast iron	oak
Flat ends	128	179	438	28
Hinged ends	157	220	537	
Round ends	203	284	693	

and the limit $\frac{l}{r}$ beyond which Euler's formula is to be used is

Flat ends	218	195	122	128
Hinged ends	178	159	99	
Round ends	138	123	77	

It will be noted that the values of f as given above are less than the average values, which may be taken as

	Ultimate strength. lbs.	Elastic limit. lbs.	Modulus of elasticity. lbs.
Wrought iron	55,000	25,000	27,000,000
Mild steel	150,000	50,000	27,000,000
Cast iron	90,000	20,000	16,000,000
Timber	8,000	3,000	12,000,000

and the convenience of the above form of this formula for rapid calculation will be seen, say for instance, with wrought iron, where $E = 27{,}000{,}000$ and $f = 42{,}000$ lbs.

Flat ends $\begin{cases} l \div r < 218,\ P \div A = 42{,}000 - 128\, l \div r \\ l \div r > 218,\ P \div A = 666{,}090{,}000\, r^2 \div l^2 \end{cases}$

Hinged ends $\begin{cases} l \div r < 178,\ P \div A = 42{,}000 - 157\, l \div r \\ l \div r > 178,\ P \div A = 444{,}150{,}000\, r^2 \div l^2 \end{cases}$

Round ends $\begin{cases} l \div r < 138,\ P \div A = 42{,}000 - 203\, l \div r \\ l \div r > 138,\ P \div A = 266{,}490{,}000\, r^2 \div l^2 \end{cases}$

Theodore Cooper adopted the straight line formula in his specifications, but the constants he used are somewhat different from the above, and the condition is laid down that the length of any compression member is not to exceed 45 times the least width.

The following gives the allowable compression per square inch on wrought iron of the section within this limit:

For chords $\begin{cases} 8{,}000 - 30\frac{l}{r} \text{ for live load stresses} \\ 16{,}000 - 60\frac{l}{r} \text{ for dead load stresses} \end{cases}$

For all posts $\begin{cases} 7{,}000 - 40\frac{l}{r} \text{ for live load stresses} \\ 14{,}000 - 80\frac{l}{r} \text{ for dead load stresses} \\ 10{,}500 - 60\frac{l}{r} \text{ for wind stresses} \end{cases}$

For lateral struts $9{,}000 - 50\frac{l}{r}$ for assumed initial stress

The "Parabola" formula is

$$\frac{P}{A} = f\left[1 - \frac{f}{4n^2E}\frac{l^2}{r^2}\right]$$

where $\frac{l}{r} < n\sqrt{(2E \div f)}$

beyond which Euler's formula is to be used. This may also be written in the form:

$$P \div A = f - k\, l^2 \div r^2$$

Where f = wrought iron 34,000
mild steel 42,000
cast iron 60,000
white pine 2,500
short leaf yellow pine 3,300
long leaf yellow pine 4,000
white oak 3,500

and k =

	wrought iron	mild steel	cast iron	white pine	short leaf yellow pine	long leaf yellow pine	white oak
Pin ends	0·67	0·97	$\frac{25}{4}$				
Flat ends	0·43	0·62	$\frac{9}{4}$	0·6	0·7	0·8	0·8

limit of $l \div r$ =

	wrought iron	mild steel	cast iron	all timbers
Pin ends	170	150	70	
Flat ends	210	190	120	60

but for timber $l^2 \div d^2$ is used after k, instead of $l^2 \div r^2$.

Merriman's formula is

$$P \div A = f \div (1 + (f l^2 \div n^2\, E\, r^2)$$

with the following values

f = as before in the "Parabola" formula.

$\frac{f}{n^2 E}$ =

Wrought iron	pin ends	=	1 ÷	12,700
	flat ends	=	1 ÷	20,000
Mild steel	pin ends	=	1 ÷	10,825
	flat ends	=	1 ÷	17,000
Cast iron	round ends	=	1 ÷	2,400
	flat ends	=	1 ÷	6,666
White pine	flat ends	=	1 ÷	1,000
Short leaf yellow pine	flat ends	=	1 ÷	1,180
Long leaf yelow pine	flat ends	=	1 ÷	1,200
White oak	flat ends	=	1 ÷	1,090

In timber again the $l^2 \div d^2$ is used instead of $l^2 \div r^2$, and this is practically the same thing as Ritter's Rational Formula

$$P \div A = f_1 \div (1 + f\, l^2 \div m\, \pi\, E\, r^2)$$

When f = greatest compressive unit stress on the concave side
f = unit stress at the elastic limit
m = 4 for both ends fixed
2¼ one end round, other fixed
1 both ends round
¼ one end fixed, other pin

The formula proposed by Moncrieff (Am.Soc.C.E., June, 1901) is for free ended columns.

$$R = \sqrt{\left\{\frac{48\,E}{5\,F_c + f_d\left(\frac{c\,e}{r^2} - 5\right)}\left(\frac{F_c}{f_d} - 1 - \frac{c\,e}{r^2}\right)\right\}}$$

for failure by excessive intensity of fibre stress, or in other words, for failure by compression, and

$$R = \sqrt{\left\{\frac{48\,E}{5\,F_t - f_d\left(\frac{c\,e}{r^2} + 5\right)}\left(\frac{F_t}{f_d} - 1 + \frac{c\,e}{r^2}\right)\right\}}$$

for failure by instability, or in other words by failure by tension. If for fixed ended columns the figure 2 is placed before the radical sign, but the author says in actual practice a true fixed ended column rarely, if ever, exists.

$R = l \div r$
E = modulus of elasticity
r = radius of gyration in the direction in which the column bends
c = distance of extreme fibre from neutral axis of section
$f = M_c \div I$
f_d = average stress or direct load per square inch.
e = eccentricity of the load, distance from the axis of the column at the ends.
F_c = maximum (compressive) fibre stress
F_t = minimum (tension) fibre stress

For *Cast Iron*, E = 14,000,000 lbs.
F_c = ultimate crushing strength = 115,000 lbs. per sq. in.
allowable, 12,000 lbs. per sq. in.
F_t = ultimate tensile strength = 15,000 lbs. per sq. in.
value of $c\,e \div r^2 = 0{\cdot}6$ corresponding to eccentricity of loading of 0·3 times the radius of gyration in solid cylindrical column.

For *Wrought Iron*, $E \div$ 28,000,000 lbs.
$F_c \div$ ultimate 48,000 lbs. (45,000 to 50,000) per sq. in., allowable 18,000
$c\,e \div r^2 = 0{\cdot}6$ for lower limit, 0·15 for upper limit.

For *Mild Steel*, E = 30,000,000 lbs.
F_c = 64,000 lbs. (60,000 to 70,000), 24,000 allowable
$c\,e \div r^2 = 0{\cdot}6$ for lower limit, 0·15 for higher limit.

For *Hard Steel*, E = 30,000,000 lbs.
F_c = 100,000 lbs., allowable 36,000
$c\,e \div r^2 = 0{\cdot}6$ and 0·15.

For *Yellow Pine* and *Pitch Pine*,
E = 2,200,000 lbs.
F_c = 6,000 lbs., allowable 2,000
$c\,e \div r^2 = 0{\cdot}075$ and 0·15 for upper limit curve
$c\,e \div r^2 = 0{\cdot}6$ for lower limit curve

For *White Pine*, E = 1,400,000 lbs.
F_c = 4,000 lbs. ultimate, allowable 1,300
$c\,e \div r^2 = 0{\cdot}075$ and 0·15 upper limit
= 0·6 lower limit.

For *French* or *Dantzic Oak*,
E = 1,200,000
F_c = 6,000 ultimate, 2,000 allowable
$c\,e \div r^2 = 0{\cdot}075$ and 0·15 upper limit
= 0·6 lower limit.

Mr. Mayer, in the correspondence following Mr. Moncrieff's paper, stated that for dead loads it is desirable that the stress shall not exceed one-half the elastic limit. For short steel or wrought iron columns the elastic limit is about 0·6 the ultimate strength, and therefore the dead load stress should be about 0·3 of the ultimate strength, which is about equal for tension and compression. A curve therefore which starts at 0·3 for short columns and approaches one-half the ultimate strength for long columns would be desirable, but the straight line equation

$$u = a \quad b\,l \div r$$

where a = 0·3 ultimate strength, $b = \frac{a}{250}$, will give the proper unit stress u for columns of less than 150 radii of gyration. The formulas suggested are

for iron 14,000 — $56\,l \div r$
for medium steel 18,000 — $72\,l \div r$

The formula suggested by Mr. J. R. Worcester (Am.Soc. C.E., January, 1908) gives a circular or elliptical curve and is

$$A = B \sqrt{\left\{1 - (l^2 \div (C\,r)^2)\right\}}$$

where A = allowable stress
r = least radius of gyration
B = maximum stress at $l \div r = 0$
C = maximum value of $l \div r$ allowed

and the formula appears for safe loads ($\frac{4}{15}$ ultimate)

$$= 12{,}000 \sqrt{\left\{1 - (l^2 \div (120\,r)^2)\right\}}$$

As regards the strength of timber Stoney gives the following as the crushing strength of dry timber:—*Red Deal* 6,586 lbs. per sq. in., *White* 7,293, *Spruce Fir* 6,819, *Mahogany* 8,198, *Quebec Oak* 5,982, *English Oak* 10,058, *Pitch Pine* 6,790, *Yellow Pine* 5,445, *Red Pine* 7,518, *Willow* 6,218; but the figures were obtained from tests of small specimens of a length not more than twice the least diameter and in which there is certainly more homogeniety than in the larger scantlings used in buildings and bridges, where knots and other defects are found which are absent in the smaller tests. Perhaps 50 per cent. of the above figures would be about correct for actual use in works for the ultimate strength, and of course a smaller fraction again of these for actual or working loads.

As regards actual cases we may mention the Landore Viaduct, constructed by Brunel of creosoted American pine, where a stress of 373 lbs. was allowed in compression, although some parts were stressed to 560 lbs. per sq. in.

At the Innoshannon lattice timber bridge on the Cork and Brandon R. 484 lbs. was allowed in compression.

Haupt considered 800 lbs. as a safe stress per sq. in. for permanent loads, and Mosse stated that 900 lbs. per sq. in. for pine is used in American timber framing.

Navier and Morin, the French authorities, state that the working stress on timber posts should not be greater than $\frac{1}{10}$ the breaking stress if the timber is exposed to weather, or to $\frac{1}{8}$ if covered over, such as in buildings, etc. For merely temporary purposes, and where there are no shocks to be provided against, probably $\frac{1}{4}$ the ultimate stress would be safe to put upon the timber.

Deans on "Erection" in Du Bois' large work says that yellow pine compression members may be stressed as high as 11,000 lbs. when the proportion of length to least side is not more than 40, and that for struts over this proportion of length the unit stress should be reduced by an amount which gives the stress in white pine as about $\frac{2}{3}$ that allowable in yellow pine.

u = 1,500 — $18\,l \div d$ for yellow pine
= 1,000 — $18\,l \div d$ for white pine, where

u = unit stress, l = length in inches, d = least side in inches. This is for quiescent loads, and where moving loads are carried the stress should be reduced by 20 % of the above. In no case should the length be greater than 50 times the least side.

Schneider in the *Builder's Journal* gives the following as

the unit stress in lbs. per sq. in. in columns under 12 diameters in length :—

c = White oak = 1,000
Long leaf pine = 1,000
White pine and spruce = 700
Hemlock = 650

and says that wooden struts, the length of which exceeds 12 times the least diameter, should be calculated by the following formula :—

$$p = c \div \left\{1 + \left(l^2 \div (1000\,d^2)\right)\right\}$$

where l = length of column in inches
d = least side of column in inches.

The following rough approximation may be of use in estimating the strength of timber struts, taking the strength of a cube of any wood as unity, the strength of columns with a greater proportion of length becomes

length 12	times	least	thickness,	·833
24	,,	,,	,,	·50
36	,,	,,	,,	·33
48	,,	,,	,,	·166
60	,,	,,	,,	·083

the following being the ultimate crushing strength of various English timbers :—

Oak	3½ tons	(7,840 lbs.)
Fir	2½ ,,	(5,600 ,,)
Pitch pine	3 ,,	(6,720 ,,)
Yellow pine	2 ,,	(4,480 ,,)

The experiments of Christie give the following as the approximate strength of mild steel L T struts with ends flat :

Ratio $l \div r$	Breaking weight, lbs. per sq. in.	Ratio $l \div r$	Breaking weight, lbs. per sq. in.
20	72,000	180	19,500
40	46,000	200	16,500
60	41,000	220	14,000
80	38,000	240	12,000
100	35,000	260	10,300
120	31,500	280	9,000
140	27,000	300	7,900
160	23,000		

(To be continued.)

Locomotive Journals and Bearings.—VII.*

London and South Western Railway.

THE services between Waterloo, Exeter and Plymouth on the L. and South Western R. are in direct competition with those on the Gt. Western R., but the non-stop runs are not so long because the line is not equipped with water troughs. Fast express services are also maintained between Waterloo, Bournemouth, Southampton and Weymouth. Below Exeter the gradients are steep.

The latest express engines designed for these services by Mr. D. Drummond, M.Inst.C.E., chief mechanical engineer of the L. and South Western R., are of the six-coupled (4-6-0) type with 4 simple cylinders using steam at 175 lbs. working pressure. The cylinders are 15in. diam. by 26in. stroke, and the coupled wheels 6ft. in diam., the maximum weight on a driving axle is 16 tons 6 cwts.

Driving Axle-box, fig. 30. This box is made of wrought-iron with deep top flanges which enclose the top of the horn-block. It is 13in. between the horn faces and 10⅝in. from the centre to the top of the crown and 13⅝in. to the top of the flanges. It carries a brass step 3in. thick at the crown and fitted with three large white metal insets, the

*Previous articles in February, March, May, June, July and August, 1908.

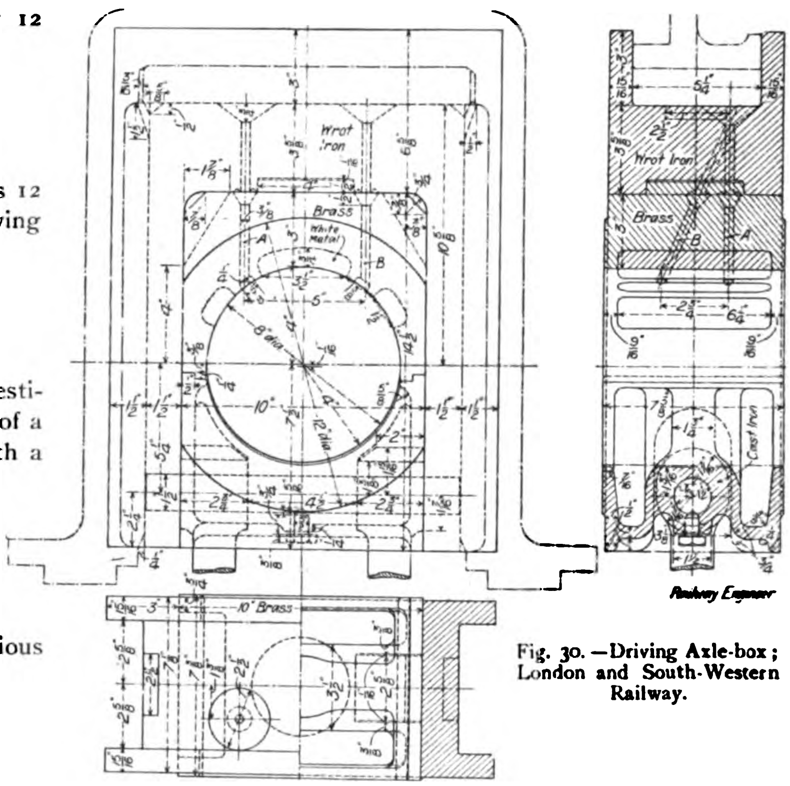


Fig. 30.—Driving Axle-box; London and South-Western Railway.

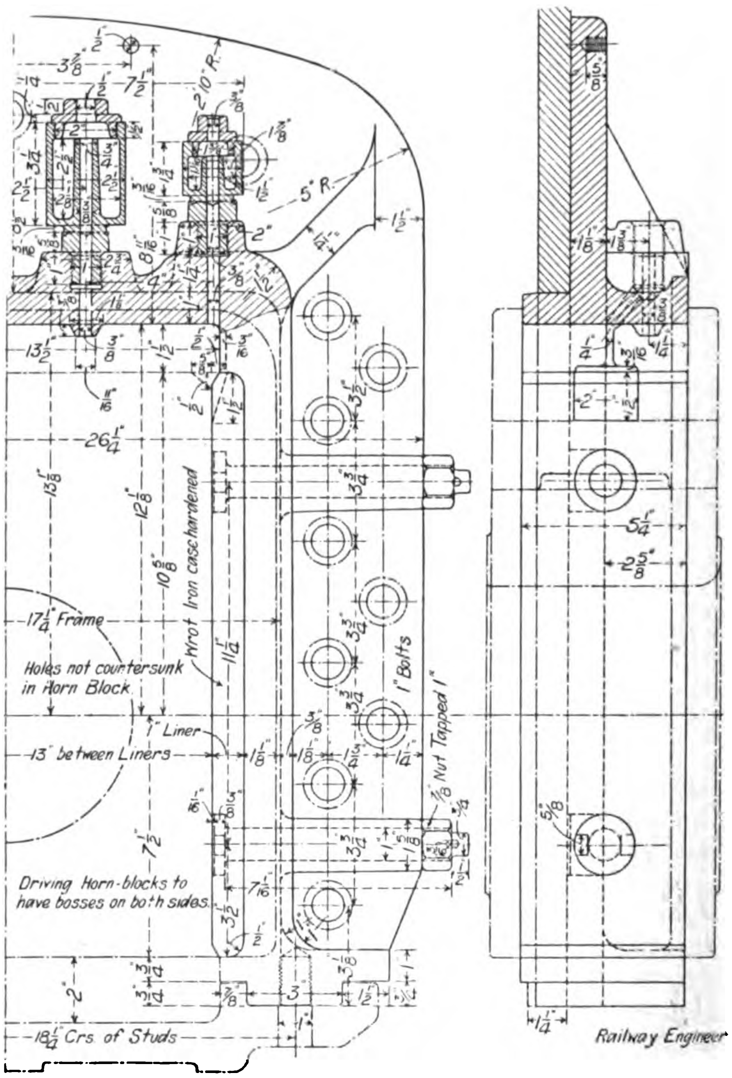


Fig. 31.—Horn Block; London and South-Western Railway.

largest of which, it will be noticed, is on the crown, the oil ways being on either side as shown. In this point Mr. Drummond's practice agrees with that of Mr. Churchward above mentioned. It is carried on a spring-hanger pin $1\frac{1}{2}$ diam. and to which it is fixed by a $\frac{5}{8}$in. steel screw.

The Horn-Block, fig. 31, carries four lubricators on the

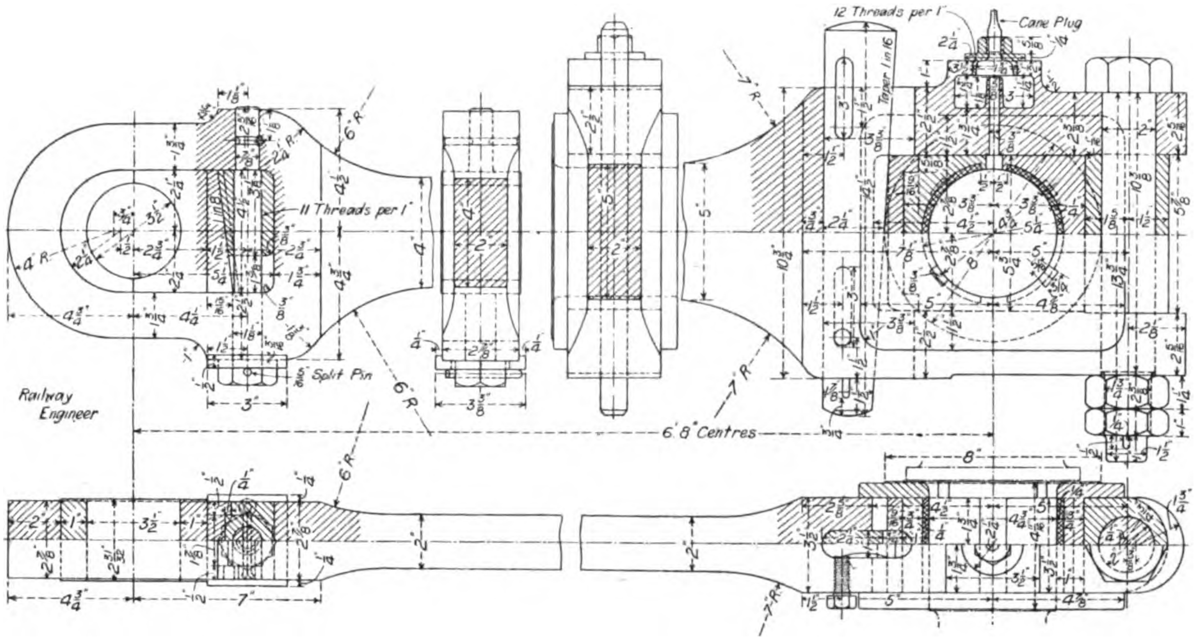


Fig. 32.—Connecting Rod; London and South-Western Railway.

(G.W.R.). The step extends below the centre line and is fitted into the cast-iron keep as shown. It is prevented from moving sideways by a projection 4in. liam. by $\frac{1}{2}$in. high which enters a recess $\frac{9}{16}$in. deep in the top of the box. inside; the two inner and larger ones supply the main bearing and the two outer and smaller ones the horn-block surfaces. The oil feeds through $\frac{3}{8}$ holes and drips into cones on the top of the axle-box and thence to the oil

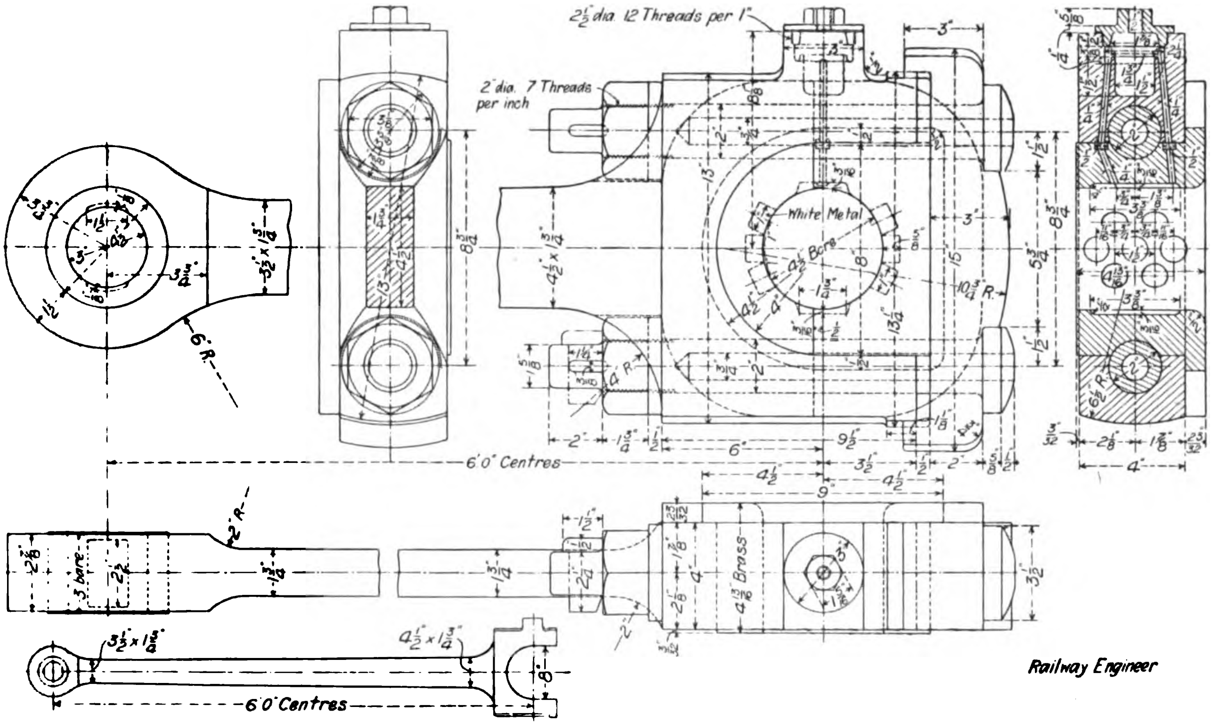


Fig. 32a.—Connecting Rod; London and South-Western Railway.

The corners are taken off clear of the fillets in the box and the bearing surface of the step in the box is further reduced as shown.

The Bearing is 8in. diam. by $7\frac{5}{8}$in. long. It is lubricated from the top and the keep is fitted with pads.

The Keep is of cast iron and fits close up to the step as channels $\frac{5}{8}$ by $\frac{1}{4}$ along the bearing as shown. For the horn block surfaces the liners ($5\frac{1}{4}$in. wide), which are of wrought-iron case-hardened, the oil drips into tapered wells 2in. wide.

Connecting-Rod, fig. 32. This is an outside rod for a four-coupled outside cylinder engine and is 6ft. 8in. between the centres. The Big-End is forked to receive the brasses

which are $5\frac{3}{4}$in. by $6\frac{3}{4}$in. The jaws of the fork are $2\frac{5}{16}$in. by $1\frac{1}{2}$in. smallest section. The bearing is made of gunmetal $4\frac{3}{4}$in. diam. by $4\frac{11}{16}$in. long. It is lined as shown, nearly all round, and for its full length in four places, with white-metal $\frac{1}{4}$in. thick. The bearing is retained in position by a

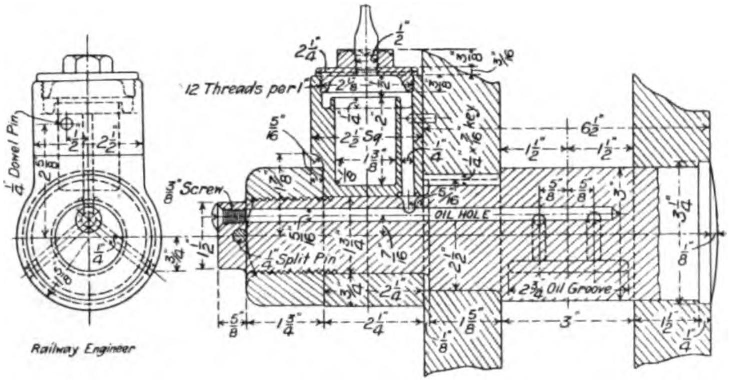


Fig. 33.—Gudgeon Pin and Lubricator; London and South-Western R.

steel keep through which passes the retaining bolt 2in. diam. secured by double nuts and a safety split cotter. The bearing is adjusted by a steel cotter ($2\frac{1}{4}$in. by 1in. middle section) tapered at 1 in 16, and which is secured in the usual way by two $\frac{5}{8}$ steel set screws and a split cotter. The adjusting cotter bears on a steel wedge piece which fits into the bearing top and bottom, it is retained in its place by the flanges of the brasses.

The Lubricator is 3in. diam. bored out of the solid, closed with a brass cover, screwed in, the filling hole being screwed for a cane plug. The feed hole is $\frac{3}{8}$in. diam. and leads to a groove along the top of bearing

The Rod is of steel, rectangular in section, with the corners rounded off to a $\frac{1}{2}$in. radius. The depth tapers from 5in. to 4in., the width 2in. being uniform.

The Small-End is of the solid eye type and contains an adjustable gun-metal bearing $3\frac{1}{2}$in. diam. by $2\frac{31}{32}$ in., the gudgeon pin being 3in. long. The adjusting wedges are tapered 1 in 8 and the screw has 11 threads to the inch. The locking washer instead of bearing against a projection fits over the rod on both sides and permits of one twelfth of a revolution of the screw.

The Small-End is lubricated from the inside of the journal as shown by the drawing of the :—

Gudgeon-Pin and Lubricator, fig. 33. The lubricator is of steel $2\frac{1}{2}$in. sq. outside cut out of the solid. The lower part is bored to fit over the end of the Gudgeon Pin by which it is bolted up to outside cheek of the Cross-Head. It is prevented from turning by a $\frac{1}{4}$in. dowel pin. The oil feeds down a $\frac{1}{4}$in. hole into a $\frac{5}{16}$in. hole drilled up the Gudgeon-Pin and from which two radial holes $\frac{1}{4}$in. diam. lead to oil grooves along the journal as shown. The hole along the Gudgeon-Pin is plugged by a $\frac{3}{8}$ countersunk screw.

Connecting Rod, fig. 32A. This rod is of the marine type which has always been favoured by Mr. Drummond though other locomotive engineers have adopted it. The rod illustrated belongs to the 4-cylinder 6-coupled express engines above mentioned. It is 6ft. long between the centres. Its Small-End bearing is 3in. diam. by 3in. bare and is similar to the rod described. The solid eye is $7\frac{1}{2}$in. diam. by $2\frac{7}{8}$in. wide and carries a gun-metal ring bush $4\frac{1}{2}$in. diam. The rod is of steel, rectangular in section, with the corners rounded off to a radius of $\frac{1}{8}$in. It tapers from $3\frac{1}{2}$ by $1\frac{7}{8}$ to $4\frac{1}{2}$ by $1\frac{7}{8}$. The Big-End bearing is $4\frac{1}{2}$ diam. by $4\frac{13}{16}$in. The brasses are of gun-metal provided with two groups of 7 circular insets of white metal arranged as shown. The bolts ($8\frac{3}{4}$ between centres) are 2in. diam. with a $\frac{3}{4}$in. hole drilled up them as far as the thread (7 to inch) and the nuts are secured by split cotters $\frac{3}{8}$ by $1\frac{1}{2}$. The brasses are retained by a steel Keep 3in. thick by 4in. on the centre line, the ends being returned over the jaws of the rod as shown. The oil cup is bored out of the solid and from it two $\frac{1}{4}$in. feed holes lead, clear of the top bolt, to a groove along the top of the bearing $\frac{3}{16}$in. deep as shown.

Crosshead and Gudgeon Pin, fig. 33A, illustrates the cast-steel Crosshead of the 6-coupled express engines. The lubricator and gudgeon pin are quite similar in arrangement to that above described.

The Crosshead is 14in. between the guide bar faces, and is provided with cast-iron slipper blocks which have 10 circular white metal insets as shown. The guide faces are 15in. by 4in. The slippers have side flanges for the bars and are

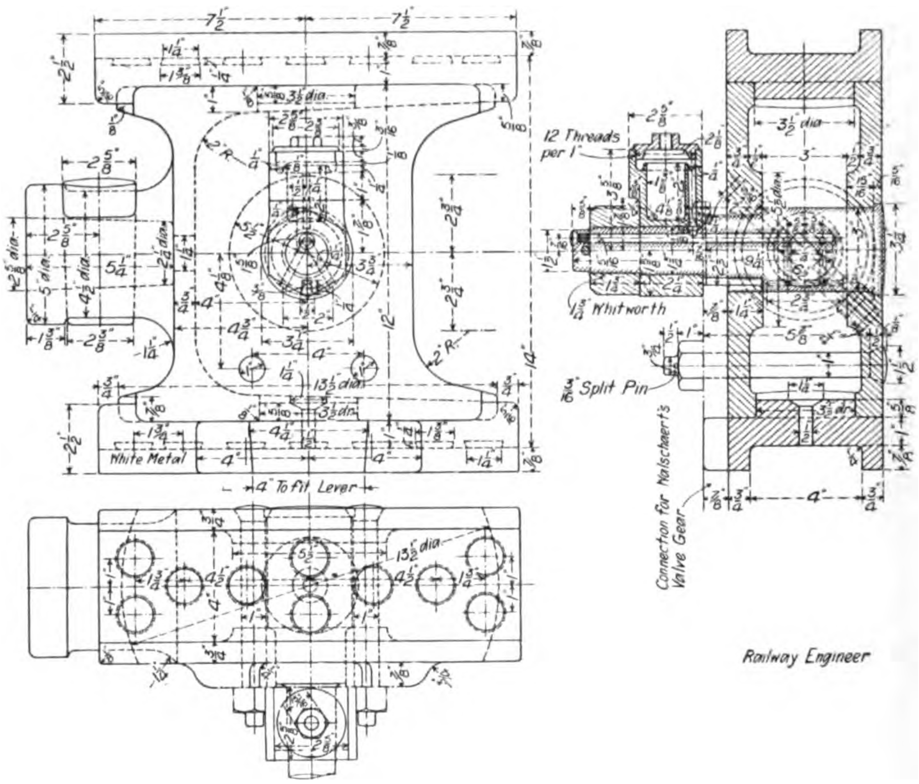


Fig. 33a.—Crosshead and Gudgeon Pin; London and South-Western Railway.

attached to the cross head by projections $3\frac{1}{2}$in. diam. and $\frac{5}{8}$ deep, fitting into central holes in the top and bottom of the crosshead, and also by end flanges turned from the same centre. The piston rod is $2\frac{5}{8}$in. diam., tapers in its socket in the crosshead to $2\frac{1}{4}$in. diam., and is secured by a tapered key $\frac{9}{16}$in. thick, and which is fastened by a split cotter. The connection for the Walschaerts' valve gear is also shown.

Coupling Rod, fig. 34, is for a four coupled inside cylinder engine. The most noticeable feature of this rod is its great length viz.: 10ft. between the centres. The eyes of

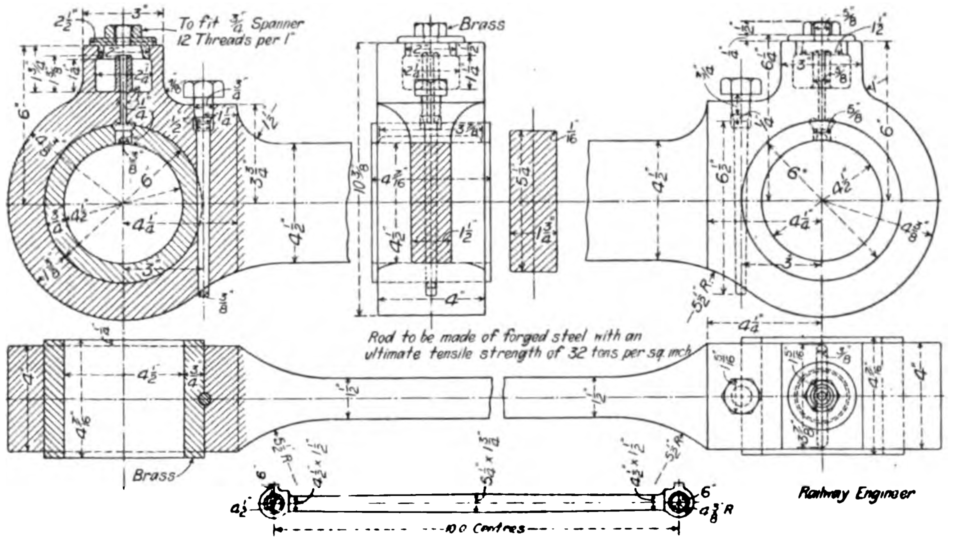


Fig. 34.—Coupling Rod; London and South-Western Railway.

the rod are 8¼ diam. by 4in. wide fitted with brass bushes ¾in. thick having having bearings 4½in. diam. by $4\frac{1}{16}$ (pins 4½) in. long. The bushes are prevented from turning by tapered steel pins held in position by ¾ steel set screws. The lubricators are solid, fitted with brass covers having the feed holes tapped ⅝ for cane plugs. The free end of the rod is retained by a washer secured by a taper pin split at the small end as shown.

The Rods are made of forged steel having an ultimate tensile strength of 32 tons per sq. inch. The section is rectangular, tapering from 4½in. by 1½in. at the ends, to 5¼in. by 1¾in. at the middle. The corners are carefully taken off to a radius of $\frac{1}{16}$in.

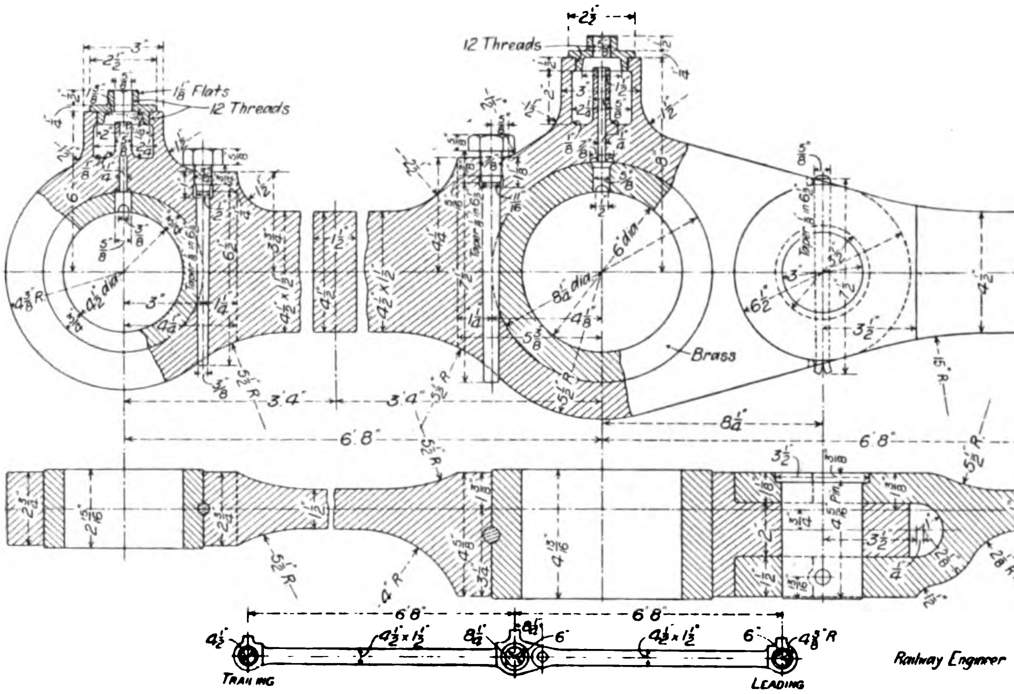


Fig. 34a.—Coupling Rod; London and South-Western Railway.

Fig. 34A illustrates the *Coupling Rod* for the 4-cylinder 6-coupled express engine. It consists of two lengths of 6ft. 8in. The driving bearing is 6in. diam. by $4\frac{13}{16}$in. and the end bearings 4½in. by $2\frac{15}{16}$in., all three have ring brass bushes. The knuckle joint is 3in. diam by 2in. All the details are quite similar to those of the 4-coupled rod above described, but the varying dimensions are given on the drawing. The rod is rectangular in section with corners taken off and is parallel 4½in. by 1½in.

(*To be continued.*)

Cape Government Railways, 1907.

Mr. T. S. McEwen, general manager of the Cape Government Railways, in his annual report, states that the capital entitled to a full year's interest amounted to £31,542,561 for 1907, as against £30,642,453 for 1906. The average number of miles open to traffic was 3,218.

Since 1903, it has been the practice to charge working expenditure each year with an amount of £252,500 for redemption in connection with additional rolling stock, locomotive workshops, steamsheds, etc., authorised under Act 42 of 1902. As, however, owing to the continued depression, Parliament has remitted the charge for the last two years, subject to the proviso that the redemption of the loan shall form a first charge against any future surplus, it has been eliminated from the accounts for 1907, and also for the comparative figures for 1906 and partially from those of 1905 and 1904, during which year only £149,308 was surrendered to the Treasury.

The following figures show the results of working for 1907, as compared with 1906:—

Total Earnings.	1907.	1906.
Passengers ...	£1,073,364	£1,187,145
Parcels and Dogs	116,156	116,9:4
Goods, Minerals and Vehicles	1,931,256	2,104,169
Cartage ...	78,798	82,334
Livestock and Horses ...	115,260	138,985
Hire of Foreign Rolling Stock	10,526	16,784
Mails ...	62,147	49,445
Telegraphs and Miscellaneous ...	13,606	13,692
Rents	56,902	55,607
Loss on Working Guaranteed Lines	11,690	7,685
(Decrease 8.03 per cent.) ...	£3,469,705	£3,772,770
Total Earnings	£3,469,705	£3,772,770
Total Expenditure (—5.7 per cent.)	2,572,634*	2,728,849*
Balance (— £146,619) ...	897,302†	1,043,921
Deduct Interest payable to Treasury	1,114,656	1,087,313
Loss, allowing for interest ...	217,354	43,392
Net Earnings per cent. on Capital	£2 16 11	£3 8 2
Or a decreased percentage of ...	£0 11 3	—

The number of train miles run, 8,347,000, shows a reduction of 9.35 per cent.

The earnings per train mile were 8s. 3·8d., an increase of 1½ per cent., and the expenditure per train mile 6s. 2·od., an increase in expenditure of 4·1 per cent.

The figures indicate that the revenue still continues to decrease, and, as the railway earnings may be assumed to reflect fairly accurately the trade of the Colony, it is evident that the change for the better has not yet commenced, and this is confirmed by the falling off in the receipts for the opening months of

*These amounts do not include the annual instalments of £252,500 for redemption of rolling stock, &c, authorised under Ac 42 of 1902.

†Includes £231 net earnings of Mossel Bay-George Line.

the current year. Under these circumstances it is proposed to reduce train service where in excess of requirements, to increase the rates on certain commodities which are at present carried at exceptionally low rates, such as livestock, meat, fencing, fertilisers, fruit, vegetables, South African wheat, meal and flour, imported produce, wool, skins, hides, together with an increased rate somewhere in proportion to the value on ostrich feathers, also on such other goods as may be considered able to bear a higher rate, and to withdraw certain passenger concessions such as Parliamentary passes.

The total as compared with 1906 shows a decrease of 8.03 per cent., the falling off between 1906 and 1905 being 6·78 per cent. This, however, has been in a measure counteracted by the reduction of expenditure by 5.7 per cent. A reduction of expenditure to the extent of nearly £2,000,000 has had a most serious reactionary effect upon the general trade of the Colony.

The purely South African traffic having dropped from 825,806 tons in 1906 to 770,408 tons in 1907, and the imported traffic from 890,876 tons to 768,855 tons.

The number of passengers, 18,067,524, carried shows a decrease of 12.68 per cent.

The following statement gives the details of the expenditure :—

	Amount.	Per Train Mile.	
	£	s.	d.
Maintenance of Way, Works and Stations...	409,525	0	11·8
New Works (Betterment) ... ,,... ...	10,416	0	0·3
Relaying, Regrading, and Strengthening of Bridges (Betterment)	44,689	0	1·3
Locomotive Charges	862,103	2	0·8
Carriages and Wagons (Repairs and Renewals)	270,693	0	7·8
Additional Rolling Stock, Workshops, Steam Sheds, etc.	—		—
Traffic Expenses	628,380	1	6·1
Compensation	13,403	0	0·4
Cartage	78,782	0	2·2
Harbour Board Tonnage Allowance	33,407	0	1·0
General Charges	76,946	0	2·2
Telegraphs, Maintenance of	14,818	0	0·4
Railway Schools	5,829	0	0·2
Sick Fund	32,481	0	0·9
Forest Plantations (Betterment)	6,031	0	0·2
Transmission of Telegrams	46,698	0	1·3
Postage	4,590	0	0·1
Pensions	27,810	0	0·8
Loss on working Refreshment Department for year 1906, but charged to Maintenance and Working in 1907	4,906	0	0·2
Miscellaneous	1,127	0	0·0
Decrease 5·72 per cent.	£2,572,634	6	2·0

In accordance with the policy which has obtained for the last three years the coal contracts, with the exception of a very small percentage, have been confined to South African coal. Contracts were entered into for 129,520 tons, of which 112,120 tons have been consumed at an estimated extra cost of about £17,000 over the amount which would have had to be paid for other South African coal. This is one of the cases where the Department should be reimbursed the amount in question from the general revenue of the Colony for supporting this industry.

It is strongly recommended that the work of regrading should be steadily continued on all the main lines with a view to reducing the cost of haulage. The heavy passenger traffic from Cape Town is specially handicapped by the gradients between Touws River and Dwyka, and, even with the present reduced traffic over this section, by an expenditure of £276,000, a saving of £8,700 per annum could be effected after payment of interest on the cost of the work. By regrading a portion of this section from Dwyka to Grootfontein at a cost of £54,000 there would be a saving of £2,900 per annum, after payment of interest. Should the traffic increase, the saving effected will be greater in proportion, and should work have to be found for relief purposes or for convicts, this should be taken in hand in preference to the construction of new lines, which are not likely to pay even working expenses for many years. In one case there is a sound financial proposition in which a return at once accrues on the completion of the section, as against a certain loss for many years to come, which the reduced earnings on the main lines are, during depressed times, unable to counterbalance.

The total area of railway sleeper plantations on the 31st December, 1907, was 11,670 morgen, as compared with 10,637 morgen in 1906, a further area of 1,031 morgen of grass lands, situated at Upper Kabusie, in the Division of Stutterheim, having been set aside for sleeper plantation purposes during the year. Planting in the several areas is being steadily proceeded with and satisfactory progress is reported, notwithstanding that the expenditure has been reduced to £6,031, or a reduction on the previous year's expenditure of £5,872.

It is pleasant to observe from the statement of accounts that a sum has been placed to the credit of revenue of £423 14s. 7d. on account of the better prices obtained for the lease of everlasting flower areas, and the increased sale of transplants from Elgin.

The following tables afford a comparison of the unit and ton mileage statistics for the years 1904—1907 :—

PASSENGERS.

Year.	Receipts per Unit Mile. d.	Expenditure per Unit Mile excluding Extraordinary Expenditure and Interest. d.	Net. d.	Average Distance Travelled by each Passenger.	Average Number of Passenger Units carried by each Train.
1904	·894	·811	·083	15	85
1905	·895	·704	·191	16	84
1906	·866	·751	·115	17	83
1907	·857	·790	·067	18	77
GOODS.					
1904	1·619	1·126	·493	183	75
1905	1·565	·927	·638	186	79
1906	1·699	·956	·743	163	73
1907	1·682	·935	·747	163	81

In regard to the passenger traffic it will be observed that the receipts per passenger unit have fallen from ·866d. in 1906 to ·857d. in 1907. This is accounted for by the largest percentage decrease in numbers being in first-class, together with the falling off of ordinary fare paying passengers in comparison with those taking advantage of excursion facilities at the recognised holiday times, and the many agricultural shows held all over the Colony.

The slight increase of ·09d. in the expenditure per passenger unit mile is due to the heavy decrease of six in the number of units per train as compared with the previous year, and shows that the train service is now, unfortunately, in excess of the traffic requirements.

In regard to the goods traffic the receipts per ton mile show a very slight decrease of ·017d. on that of the previous year, but against this the expenditure per ton mile has decreased by ·021d., thus more than making up for the drop in receipts. The average distance each ton of goods was carried remains the same as for 1906, viz., 163 miles, and the average number of tons carried per train has increased from 73 in 1906 to 81 in 1907, this indicating that the constant attention which has been paid to loading trucks has resulted in a satisfactory increase in the tonnage carried. Special attention has also been given to the tranship traffic and a great improvement in the truck load has been made in connection with fruit.

Special attention is drawn to Ox-Wagon Competition, which is still very strongly in evidence on the Midland and Eastern Systems, particularly the latter. The country has saddled itself with a heavy debt in order to open up the back districts of the Colony and bring them into touch with markets for their produce, and the Government is fairly entitled to expect that such districts should make use of the railways for the conveyance of their goods. Before the construction of these branches all classes promise support, but, as soon as the railway is an accomplished fact, in many cases the very people who agitated so strongly for this means of communication still continue to make use of road transport, utilising the railway for high-rated goods which may be required in a hurry, for produce and other low-rated traffic, and for passengers. This competition shows no sign of abatement in the Native Territories where the road transport is principally in the hands of natives, who are able, owing to their limited wants, to quote rates with which the railway is quite unable to compete except at a great loss, and it is again strongly recommended that legislation be introduced inflicting a heavy, if not prohibitive tax on waybills, where the wagons compete in districts served by railways. This is seemingly the best means of reaching the people who support and encourage this competition.

The wagon should be used in its legitimate way as a feeder to the railway instead of a competitor; it is reported that traders and others are unable to procure transport for short distances at reasonable rates for their produce. The railways are able to compete by reducing rates with a view to sweeping the wagon off the road, and thus forcing the owners to take to the land or other avocations, but this method of dealing with the question will adversely affect the revenue to a large extent. As the object to be secured is the elimination of ox-wagon competition, this should be attained by carrying it out so as to increase the revenue and not make it necessary to alter the railway rates, because, as soon as the rates are reduced in one district the ox-wagon will re-

appear elsewhere, when further reductions will have to be made to deal with it at the new competitive points.

As an instance of what is done the following paragraph from the report of the Traffic Manager of the Midland System is quoted :—

"An instance has been brought to my knowledge in which it is said that a party conveying his own wool and mohair to Port Elizabeth purchased wire and other fencing material for his farm, but, instead of carrying his own purchases on the return journey, booked them by rail at a fraction less than 6d. per 100 lbs., and utilised his wagons in opposition to the railway, thereby earning 1s. 3d. to 1s. 6d. per 100 lbs. The question arises whether, under the circumstances, we are justified in continuing to convey agricultural requisites at the present exceedingly low rates."

Single Phase Electric Traction on Railways.—II.*

In the *Railway Engineer* for August last appeared a description of the works in connection with the electrification of a section of the Erie RR., and another single phase traction service by overhead transmission of 11,000 volts is the New York, New Haven and Hartford R.R.

There are many features of interest herein. One is that at Woodlawn the New Haven line joins the New York Central, whose lines, outside New York, have been electrified by the third-rail system so that the New Haven company's trains into and out of New York have had to be equipped for both systems. Another feature is that there are four tracks throughout, over which not only is there a big suburban and local service but an important high speed express service as well as goods traffic.

This work has been carried out under the supervision of Mr. E. H. McHenry, one of the vice-presidents of the company, to whom we are indebted for the accompanying photographs and the information contained herein.

The electrified portion consists of the four lines of way between Woodlawn and Stamford, a distance of 21 miles. The power-house, of which views are given in figs. 8 and 9, is situate at Cos Cob, 18 miles from Woodlawn, and on an arm of Lond Island Sound. Coal can therefore be delivered by water or rail, and there is an unlimited supply of water for condensing purposes. The equipment consists of three multiple-expansion parallel-flow Parsons steam turbines direct-connected to single-phase Westinghouse generators and provision has been made for a fourth unit. The turbines are rated at 4,500 brake horse power each, and the generators at 3,000 K.W. each. These are seen in fig. 10.

Twelve 525 h.p. Babcock and Wilcox water tube boilers have been installed. These are provided with Roney mechanical stokers, as seen in fig. 11, also Babcock and Wilcox superheaters, and deliver steam at 200 lbs. gauge

*No. 1 appeared in the August, 1908, issue.

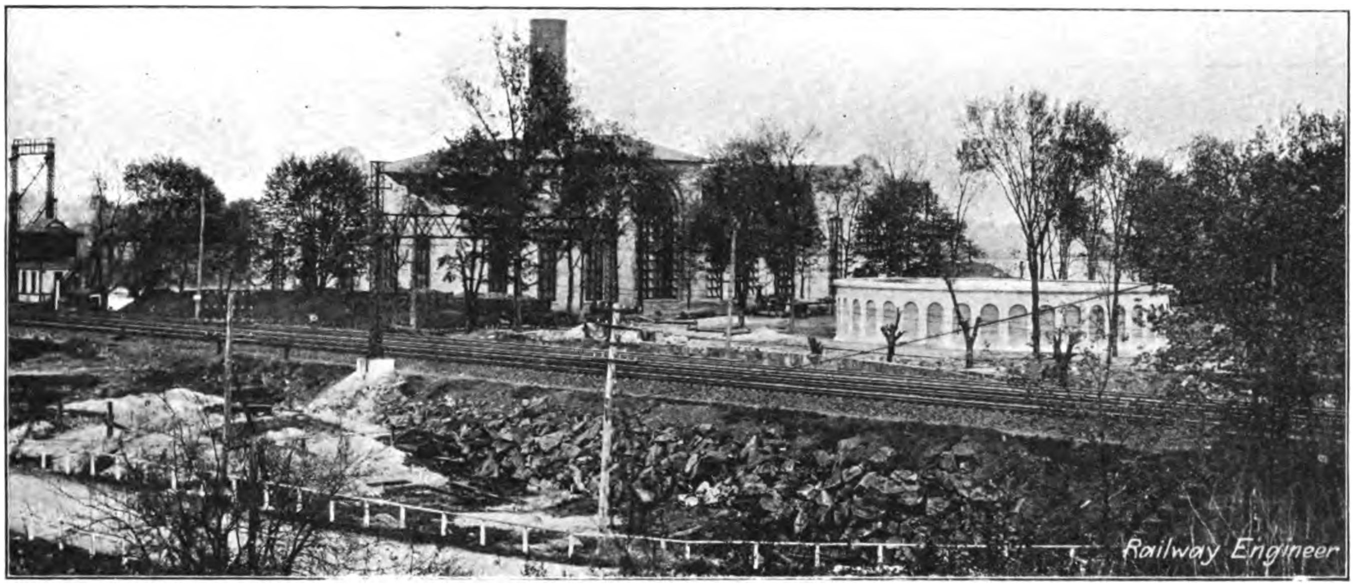


Fig. 8.

Fig. 9.

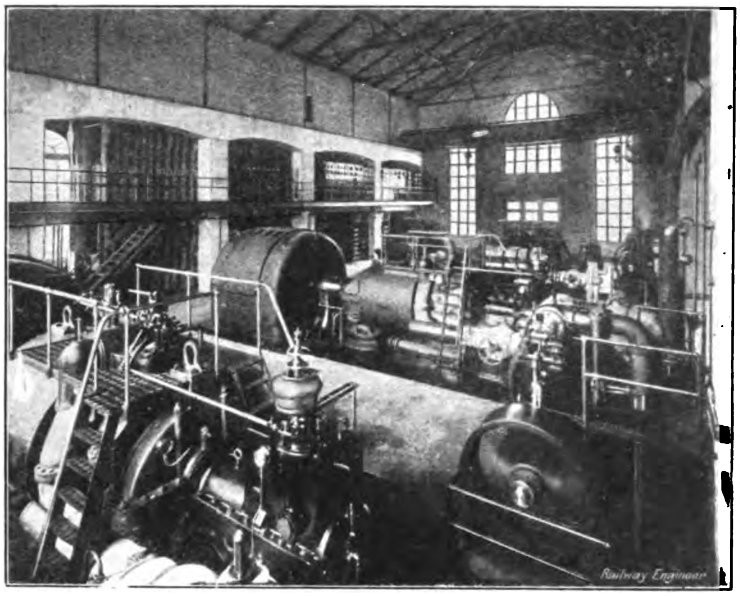


Fig. 10.

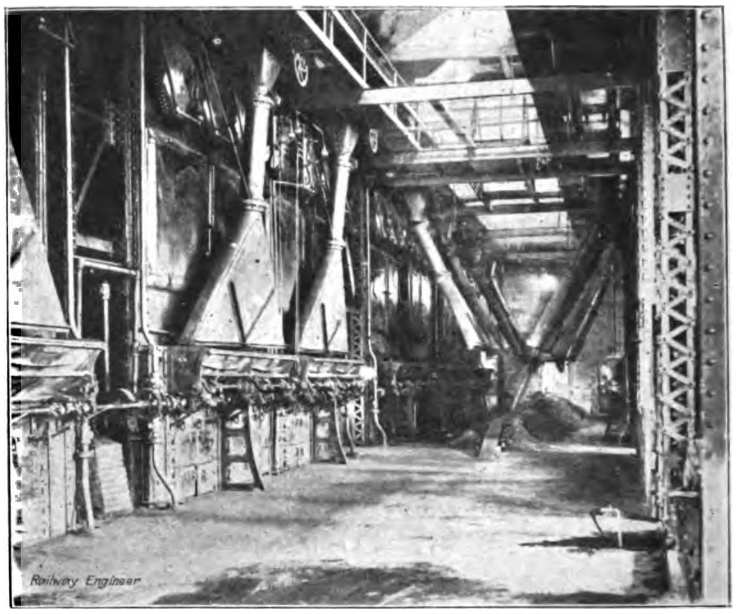


Fig. 11.

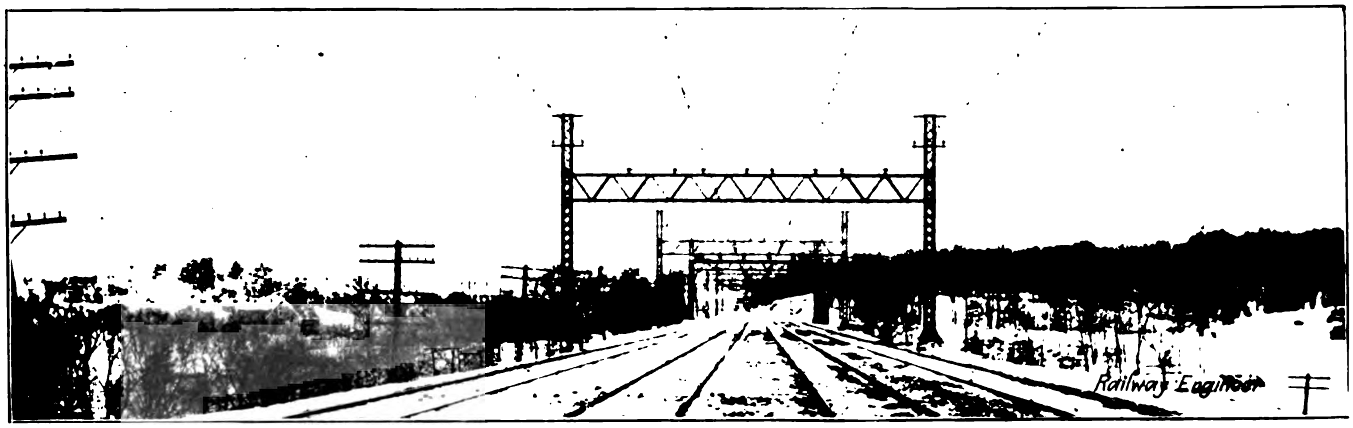


Fig. 12.

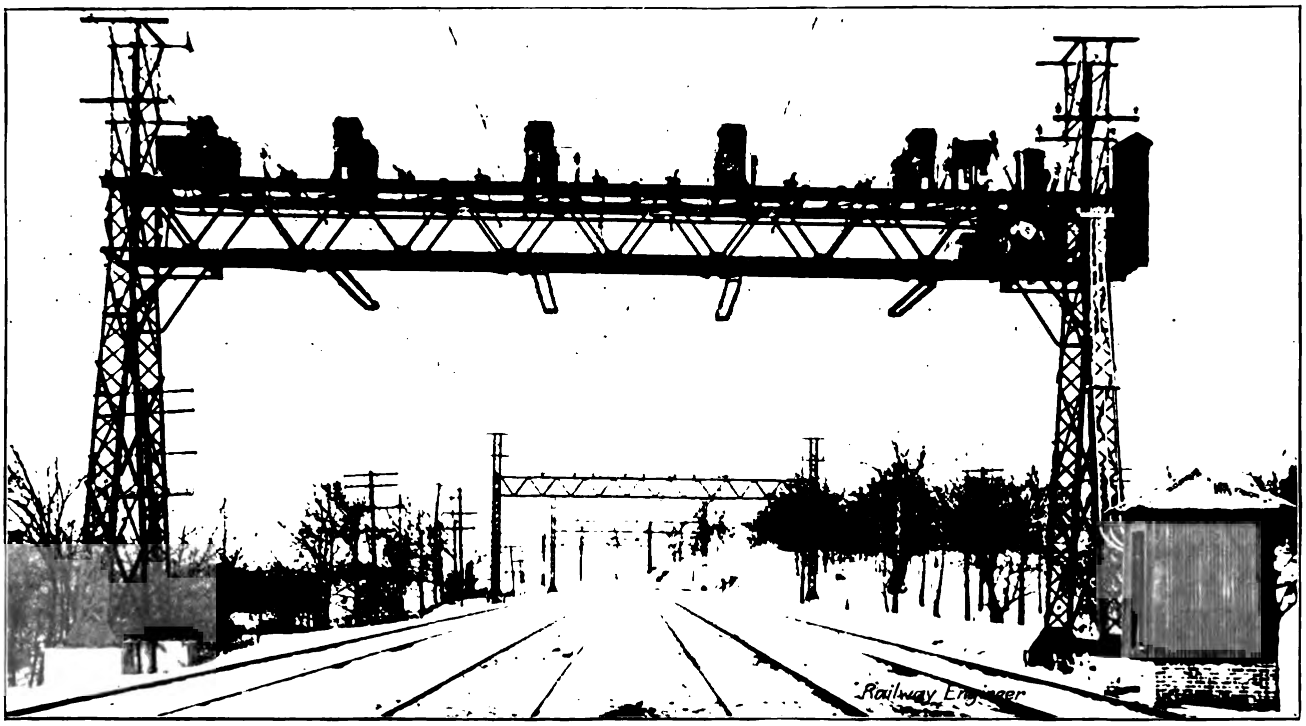


Fig. 13.

S.ngle Phase Elec ric Traction on Railways.

pressure and 125 degrees superheat. Three of Green's economisers are also used.

The main cables from each generator are run in the air

Fig. 14.

chamber under the turbine-room floor, up to the switch board gallery, seen on the left of fig. 10, and thence through selector oil-circuit breakers down to the high tension bus-bars under the switchboard gallery.

The overhead construction is of the catenary type, of which a view is given in fig. 12. Two steel cables of special high strength, supported by steel bridge structures across the lines and about 300ft. apart, carry the copper conductor by triangular hangers of varying length about 10ft. apart. Massive porcelain insulators are provided on these bridges and at intervals there are anchor bridges. The third bridge in fig. 12 is an anchor bridge, and fig. 13 is a nearer view, and fig. 14 is a side view of the top of an anchor bridge. The latter have A shape posts and are heavier than the intermediate bridges. On the anchor bridges, as seen, are carried automatic circuit breakers for isolating a section, lightning arresters, shunt transformers for operating the circuit-breakers, lighting circuits and wire and conduit for the auxiliary control circuits. On each right-hand post are two auxiliary feeder wires. On one side of each anchor bridge is a ladder from the ground.

When the writer went over this work last summer he was agreeably surprised to find that the catenary suspensions did not obstruct the driver's view as much as was anticipated. In order, however, to remove all objections the New Haven company have re-designed their signal connections, and by Mr. McHenry's further courtesy we are enabled to publish details of the same herewith.

Fig. 15 is an elevation and plan of one of the intermediate bridges which, it will be seen, spans four lines of way. The two lines on the left are for trains that may be considered as coming towards the reader and those on the right are for the opposite direction. The signals are carried on posts

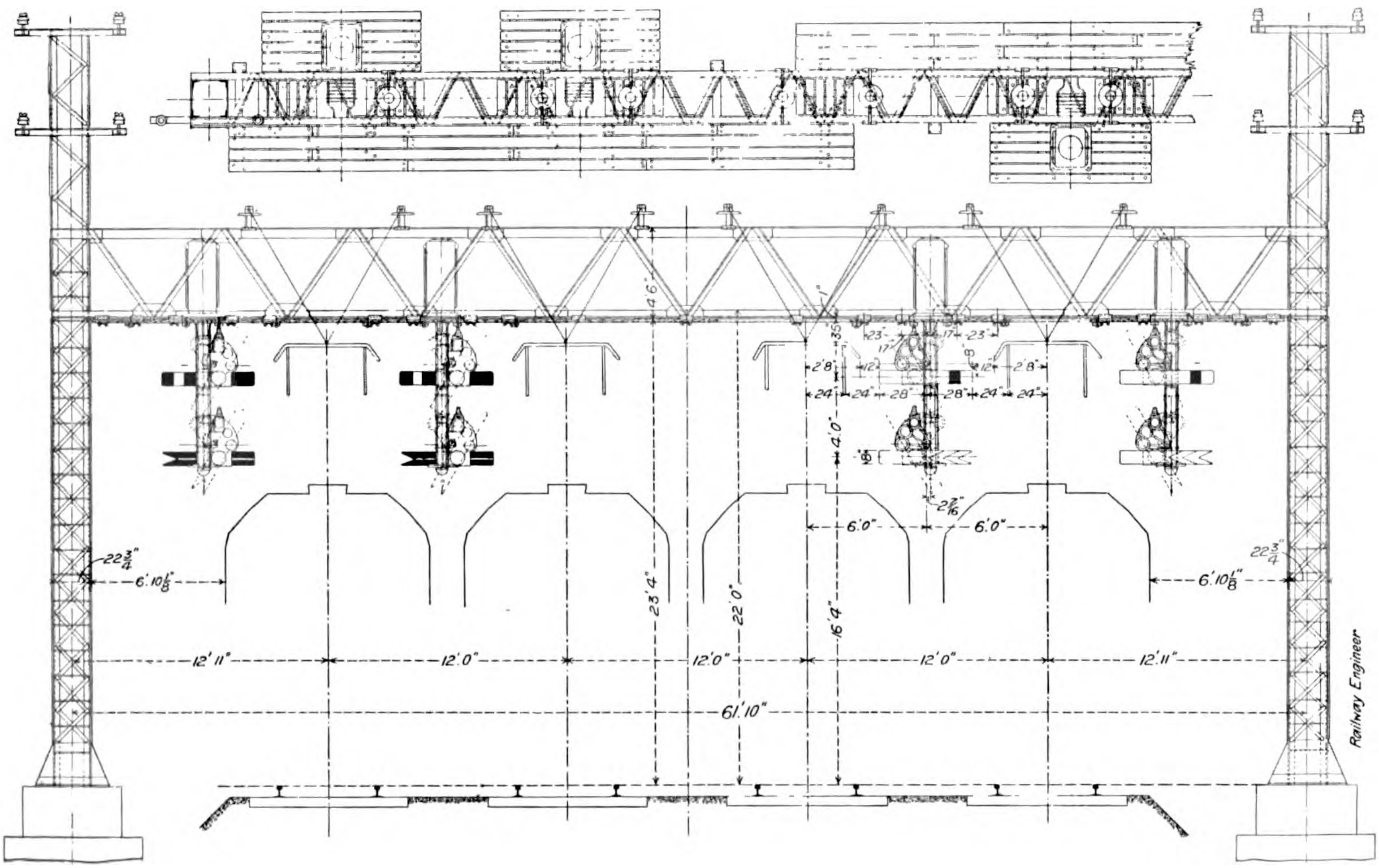


Fig. 15.

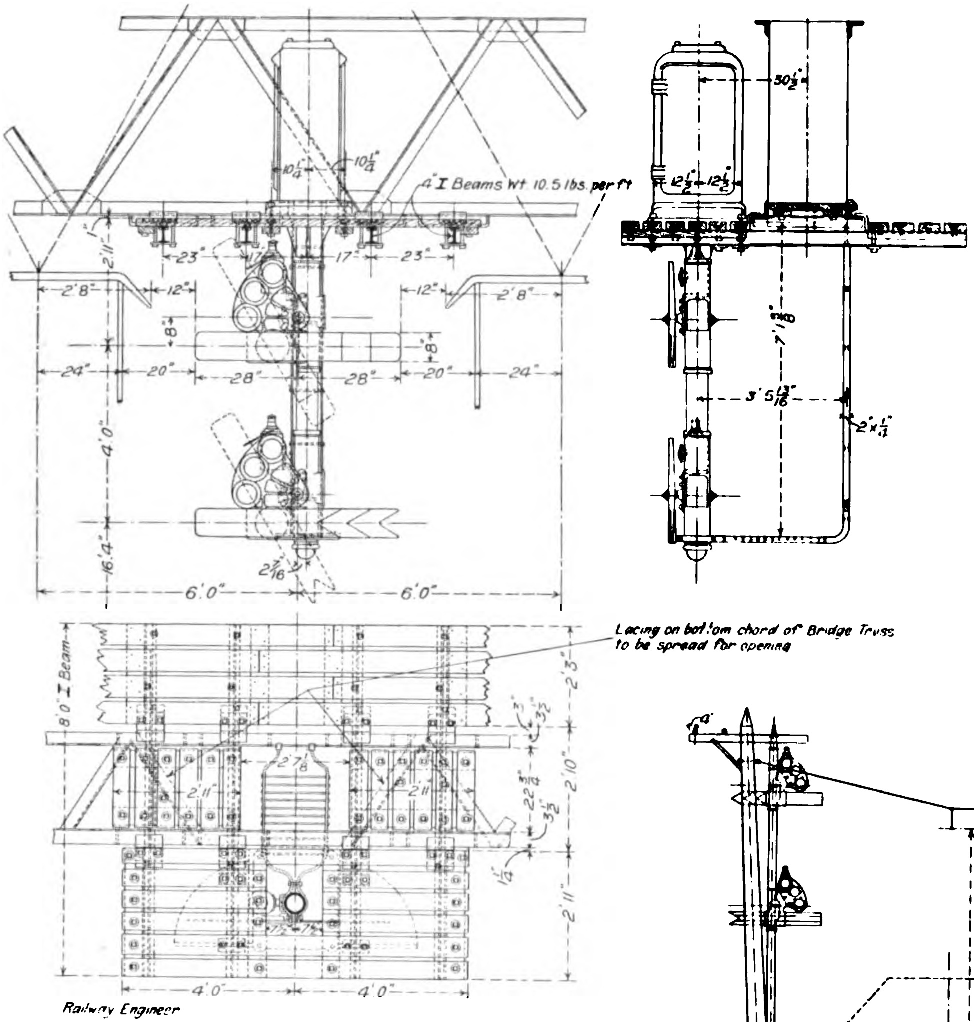


Fig. 16.

suspended from the bridge and on that side nearer an approaching train. The posts are of iron and hollow to hold the operating rods. Above the bottom truss of the bridge is situate the motor for actuating the signals. The arm is 4ft. 8in. long, is centrally balanced, and the spectacle forms part of the arm bearing casting and is on top of the arm—seen clearer in fig. 17. The lamp is fixed to the left of the post, as is usual in America, but above the level of the arm. The arm when either "on" or "off" completely clears the structure gauge. A landing runs right across the bridge, half being on one side and half on the other. From the far side of the bridge, behind each post, there is a perpendicular ladder suspended, which is curved at the bottom and the sides widened out and into which are let twelve staves, so forming a platform for the lampman and signal maintainer. This is seen clearer in fig. 16. It may here be added before leaving this subject that on certain parts of the New Haven system there are electrically-worked trains on the overhead trolley system. In such cases the poles, signal posts and signal arms are as shown in fig. 17.

(To be continued.)

Permanent Way.—III.*

Fig. 10 shows the standard Formation of the Great Eastern R. It is 30ft. wide. The ballast is 25ft. wide at the base and 22ft. wide at the top. It is 2ft. deep and covers the sleepers.

Fig. 11 illustrates the Formation on the Great Southern and Western of Ireland R., which has a gauge of 5ft. 3in. The ballast is 24ft. $2\frac{3}{4}$in. wide at the bottom and is 10in. deep; it projects to 6in. beyond the end of the sleepers and is broken to pass through a ring 2in. diameter.

The different treatment of roadbeds, according to the ballast that is available, is well demonstrated by the practice of the Missouri, Kansas and Texas RR., and which is shown in fig. 12. It will be noticed that where earth ballast is employed it is sloped from the centre line of the "four-foot," the ridge of the slopes being 3in. above the top of the sleepers, and that the ends of the sleepers are left bare. All fine and non-permeable ballast

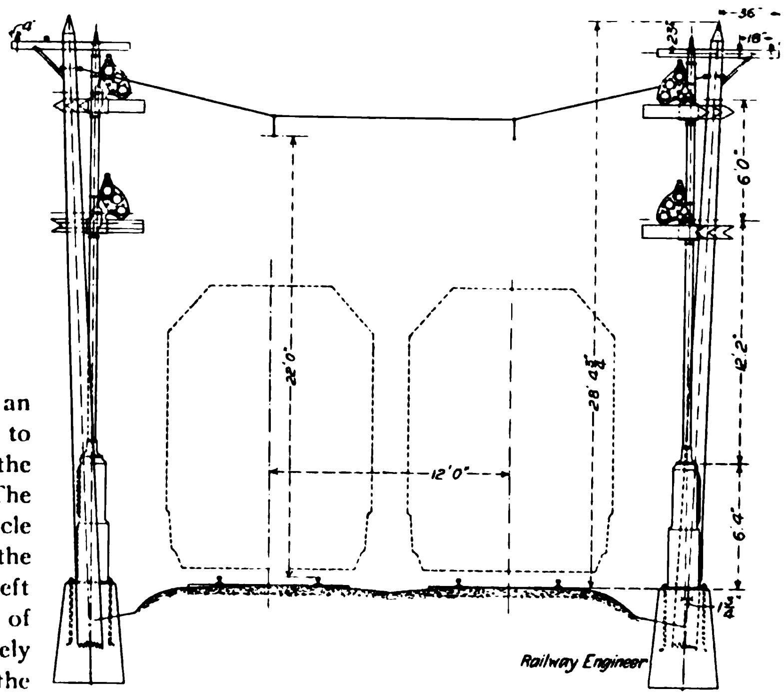


Fig. 17.

should be so treated, so that water may readily drain away.

The Chicago, Burlington and Quincy RR. has a Formation 30ft. wide on embankments and 29ft. in cuttings. The top of the Formation is level, and on this is laid the bottom ballast, which is 6in. deep at the centre-line and sloped towards the sides, being 4in. deep under the centre-lines of the "four-foots." The top ballast is 12in. deep at the centre-line and 8in. under the sleepers. In the "six-foot" the ballast is level with the top of the sleepers and is ramped to a point 4ft. 8in. from the outer rail.

The New York Central RR. has a Formation of 30ft., which is 4in. higher along the middle than at the sides. The top ballast extends to 4ft. beyond the outer rail and at the outer ends of the sleepers it is 18in. deep and comes to within 1in. of the top of the sleepers. In the "six-foot" the top ballast has a dip of 3in. along the middle, being from 1in.

*No I. appeared in August issue and No. II. in September.

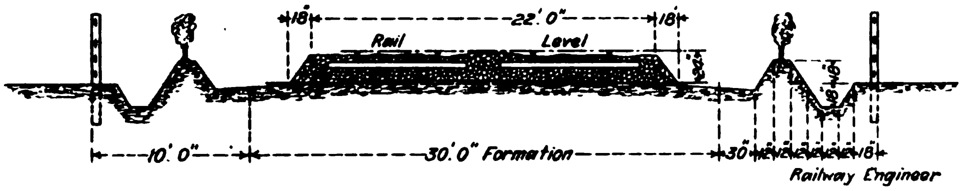


Fig. 10.

below the top of the sleeper at the end of the sleepers to 4in. below the top of the sleepers at the centre-line of the "six-foot."

In Byers' *Economics of Railway Operation*, reviewed elsewhere in this issue, we read that broken stone ballast is practically the only ballast that is fit for suburban and important passenger line service, but it is expensive in first cost, causes increased expenditure in tie renewals, and requires a considerable force for surfacing purposes. Such weeds as do grow in it must be removed by hand. The heavier the traffic the more economical stone ballast becomes, but Mr. Byers considers it uneconomical for light traffic. He then gives the following figures:—

Labour required in Stone, Slag and Gravel Ballasting.

	Stone. hours.	Slag hours	Gravel. hours.
To ballast one mile track (dressing included)	3,200	3,500	1,060
To ballast and respace one mile of track	4,200	4,500	1,760
To renew one mile of ties (2,816 ties)	3,520	4,020	2,010
To surface one mile of ties (2,816 ties)	450	670	170
To surface one mile of ties with end tamper	—	—	70

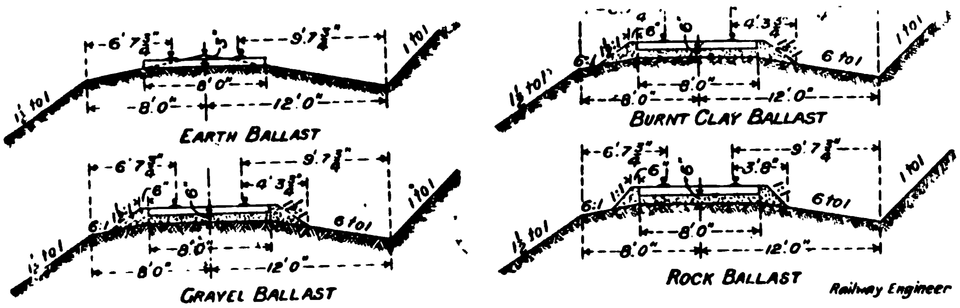


Fig. 12.

On the basis of a 10 year life for rail and ties, the work required per mile per year in different kinds of ballast, to renew ballast and ties and respace ties, is about as follows:

In stone ballast	772	hours' labour
In slag ballast	852	hours' labour
In gravel ballast	377	hours' labour

The time required for cleaning ballast is about 300 hours for gravel and 250 hours for stone.

The cost of ballast delivered, per mile, is about as follows:—Stone, $1,000; slag, $300; gravel, $200. This is on the basis of the slag being furnished free on board cars.

Mr. Byers summarises the cost per mile per annum.

	Stne.	Slg.	Grvl.
First cost of ballast...	100	30	[illegible]
Application and tie renewals ...	100	111	49
Surfacing ...	94	100	148
Cleaning ballast ...	33	33	39
Total ...	$327	$274	$256

On the East Indian R., where timber sleepers are laid, stone of about 1¾in. cube size is used.

The New South Wales Government R. double-line Formation falls from the centre-line and at lines 15ft. on either side is 6in. lower. The ballast is 2ft. deep along the centre-line and 9in. below the bottom of the sleepers. It extends to 12in. from the outer end of the sleeper and is ramped to a batter of 1 in 1. The bottom ballast is 9in. deep and is of stone about 4in. cube. The top ballast is 12in. deep and is of hard stone 2½in. gauge. It is laid 2½in. above the top of the sleepers.

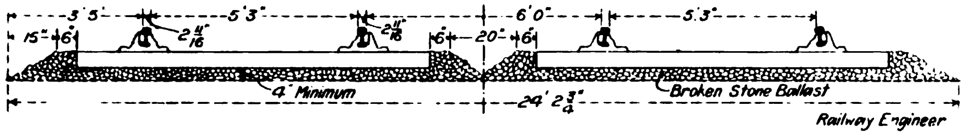


Fig. 11.

The South Australian Rs. have a Formation of 14ft. wide for single lines. The ballast is 10ft. 6in. wide at the top, 16½in. deep (9in. under the sleepers and 2½in. above). Broken limestone or quarried stone is generally employed, but occasionally river gravel, which has to pass through a ring 2½in. diam. is used.

As to the Continent, Herr Schubert, Ruling Councillor of the Bavarian State Rs., has laid down a rule that the thickness of the ballast should be equal to the clear space between two adjoining sleepers plus 20 centimetres (7·8in.). As some sleepers are 80 centimetres (31·5in.) apart, centre to centre, and they are about 25 centimetres wide, this means a depth of 55 centimetres + 20 = 75 centimetres (29·5in.). Some think that this is too much and that a thickness equal to half the clear space between two adjoining sleepers plus 10 centimetres will nearly always suffice. Mons. Ast. Civil Engineer Kaiser Ferdinands-Nordbahn says it is advisable to use a thickness of ballast not less than 30 centimetres (11·8in.) under the lower surface of the sleepers. Of this at least 15 centimetres (5·9in.) should be of material capable of being well packed. The thickness ought to be increased when the Formation is soft and if the sleepers be more than 80 centi-

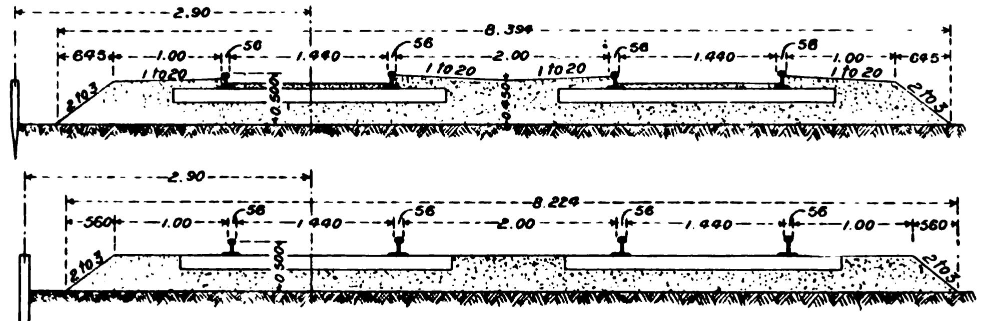


Fig. 13.

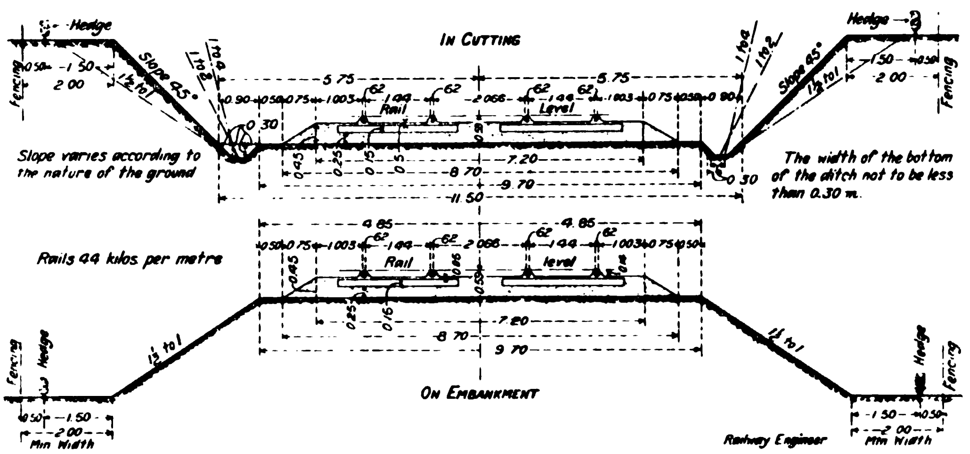


Fig. 14.

metres (2ft. 7·5in.) apart.

The general size of the stone used on Continental railways is such as will pass through a ring of 5 or 6 centimetres (2in. or 2·3in.). Some engineers prefer a ring of 4 centimetres (1·5in.).

On some railways the ballast is washed before it is spread in order to remove the earthy matter, but as this also eliminates the sand some engineers do not consider this is desirable, as sand makes the ballast more stable, and that it is better to adjust the screen so that only the finer sand is removed.

The *Chemin de fer de Ceinture de Paris* has a ballast washing plant consisting of four washers parallel with each other, carried on piles at right angles to the line. There is a revolving shaft 6·25*m*. (20ft. 6in.) long, of which 5*m*. is armed with bearers, the steel blades of which are secured by bolts so as to be readily removed when worn. The inclination of the shafts is varied as desired, and they revolve in barrels pierced with holes from 10 to 15 *mm*. ($\frac{13}{32}$ to $\frac{19}{32}$ in.) diam. passing muddy water and small debris into the troughs below. The ends of the blade rotate concentrically at a distance of 50*mm*. (2in.) from the cylindrical bottom. The violent rotation of the apparatus forces the material upwards and the stones are stirred and shaken against each other. This breaks it up and washes the stones completely, so that when they reach the upper end they are perfectly clean. They fall thence on to an inclined plane and into the ballast wagons. The water in the troughs, with its mixture of fine quartz, sand and dirt, runs into a settling tank having a superficial area of 40,000 metres (47,841 sq. yds.). Here the sand, being heavier, settles first, and on this the clay. The water, with a little clayey matter in suspension, flows from the first tank into a second, where it is further purified, and then into a third, which completes the settling, and it flows thence into the river.

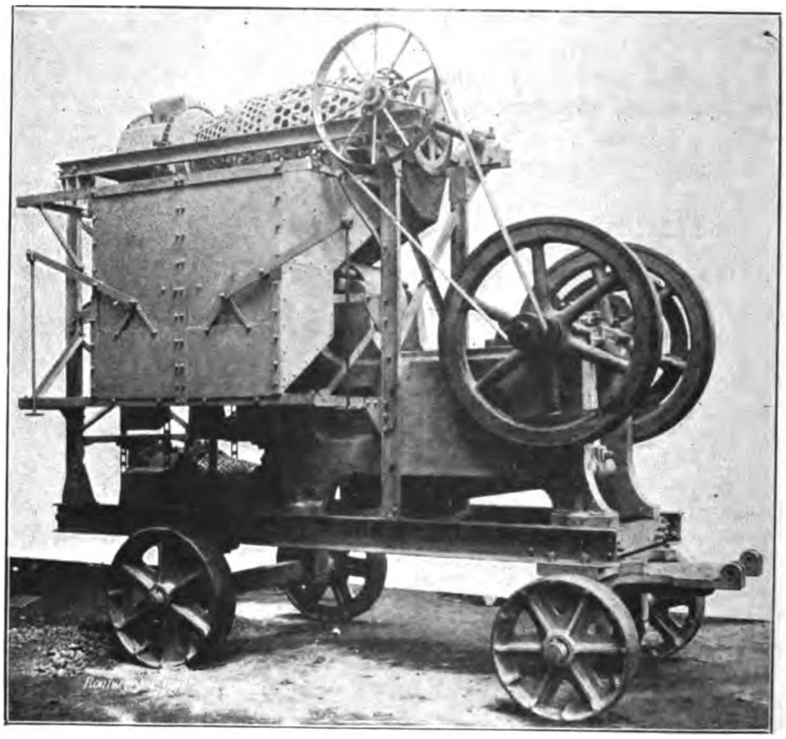


Fig. 16.

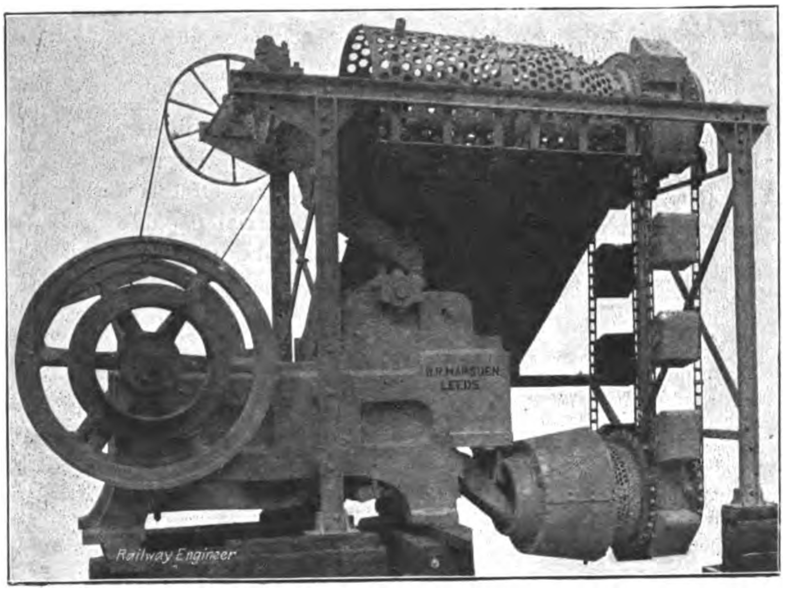


Fig. 15.

It may here be remarked that "washed" gravel is used to a small extent in America, but it is not regarded as a success. Some trials on the Grand Trunk RR. are reported to have been very disappointing.

Fig. 13 shows the Formation of the *Chemin de fer du Nord*, France. The lower illustration is known as the English section. There the ballast is level with the tops of the sleepers and the latter are not covered. Where the French section, as shown in the upper illustration, is employed the sleepers are covered in the middle and well covered at the ends sloping 1 in 20 from the rail, and the outer ends are ramped 2 in 3 from a point 1*m*. from the outer edge of the head of the rail. The ballast, which may be of washed flints, furnace slag 1 to 10 *cm*. in size, or broken stone 2 to 7 *cm*. in size, is 50 *cm*. (19·7in.) in depth from the head of the rail, and 45 *cm*. deep in the centre of the "six-foot."

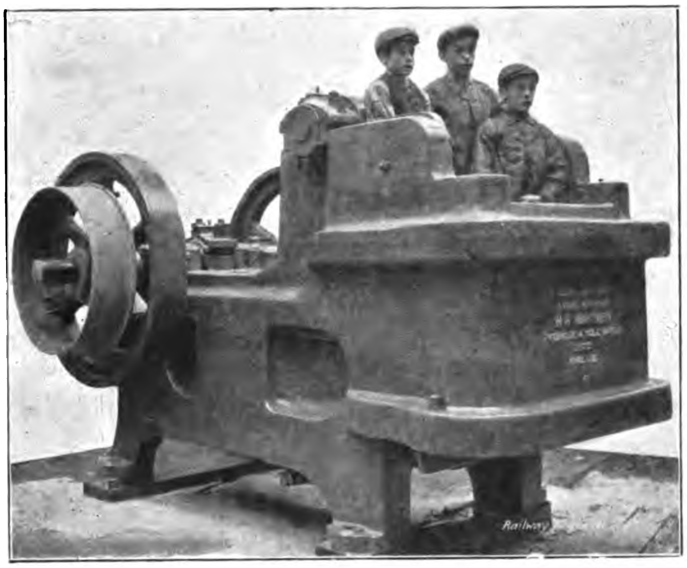


Fig. 17.

Fig. 14 shows the ballasting on the *Chemin de Fer de l'Ouest*. It requires 3,800 cub. metres of material per metre run.

The only time when the question of Ballast has been considered by the International Railway Congress was at the Paris meeting of 1900, when the following conclusions were adopted:

1. The track, strictly so called, particularly on main lines, taking into consideration the actual conditions of speed and traffic, must rest on supports having a definite and practically uniform elasticity. Now, as apart from some minor differences which may be produced by altering the sleeper spaces and the fastenings, the track is the same everywhere, while the consistency of the formation level is very variable, it is by the ballast that the required *amount of elasticity* of the track is obtained in the first instance and adjusted subsequently.

2. As a general rule, it is advisable to put little or no ballast on the sleepers, and merely pack it against their ends. But under unafvourable conditions the stability of the track may be increased by using a different cross section of ballast. Finally, further stability may be obtained by the use of sundry special methods.

3. The question of *weeding* is a disputed one. The grass should only be cut once or twice a year in districts where vegetation is very active, as it would be very expensive to keep the track quite clear, and it should only be pulled out when work is being done on the track; if the track is maintained on the periodic revision system, the weeds are pulled out during revision.

4. The determination of the best transverse section is one of the main objects in investigating ballast. There is no one definite transverse which is the best, nor are there even a limited number of typical transverse sections.

Several useful general rules may, however, be laid down:—(*a*) On a line under favourable conditions, with a rock formation level, from 25 to 30 centimetres ($9\frac{13}{16}$ to $11\frac{13}{16}$in.) of ballast should be placed below the sleepers. (*b*) The formation level should always be arranged so as to ensure good drainage.

5. In most cases, particularly with new lines, there is no choice, as different ballasts are not available; but there are also many cases in which several materials of different quality and price are available.

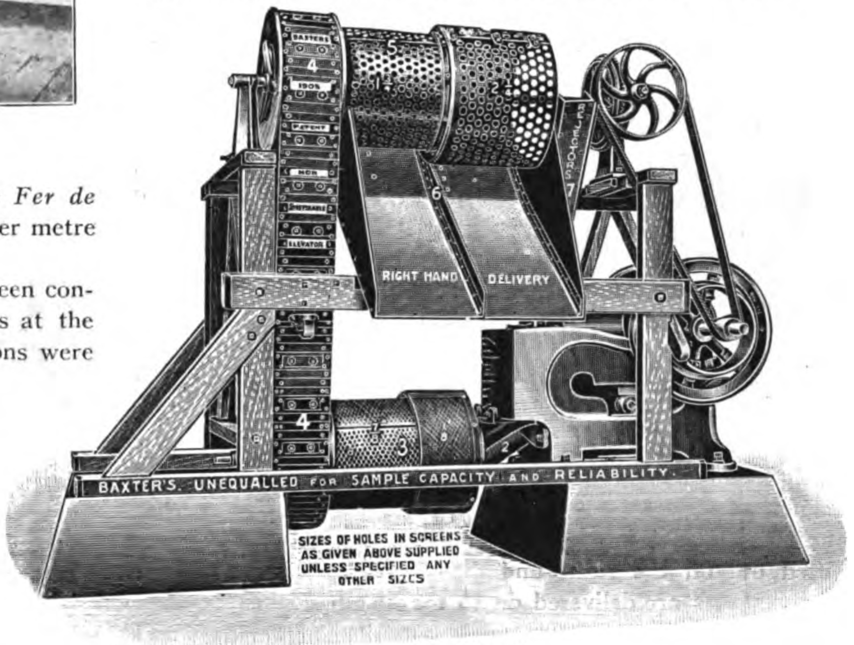


Fig. 18.

Hard broken stone, which is not affected by frost, broken blast-furnace slag, and sharp, angular gravel are the best ballasts for main lines.

On well laid-out secondary lines, on the other hand, finer materials are preferable, as they are more easy to use. Clinkers also make an excellent ballast. Coal cinders are to be reserved as much as possible for station and yard tracks and for private sidings. Gravel from pits or rivers, either wet or dry, is to be used, either as it is, or after being partially or wholly screened according to circumstances.

At the Washington meeting in 1905, on the question of the preservation of sleepers, the following remarks appear in the conclusions on that subject:—

"It is of importance to combine rigid inspection in accepting sleepers with great care in the selection of ballast; the latter must be permeable, must be capable of being well packed and the packing well maintained, and give good adhesion between the sleeper and its seat. As far as this is concerned, the measures which are best for the preservation of the wood are also best for the stiffness of the track. In order to prevent deterioration of the ballast, and at the same time to help preserve the sleepers, the careful drainage of the road-bed cannot be too carefully insisted upon in order to ensure that water may flow off properly."

Ballast Crushers.

In *The Railway Engineer* for July last, page 215, there was a description of a large stone-crushing plant supplied by Hadfields Steel Foundry Co. to a foreign railway, and capable of delivering 4,500 tons of ballast per day. In a future issue we shall publish a description of a portable stone-crushing plant made by Goodwin, Barsby and Co., of Leicester, for the Highland R.

Figs. 15 and 16 illustrate Marsden's (Leeds) new patent portable elevating screening and loading machine.

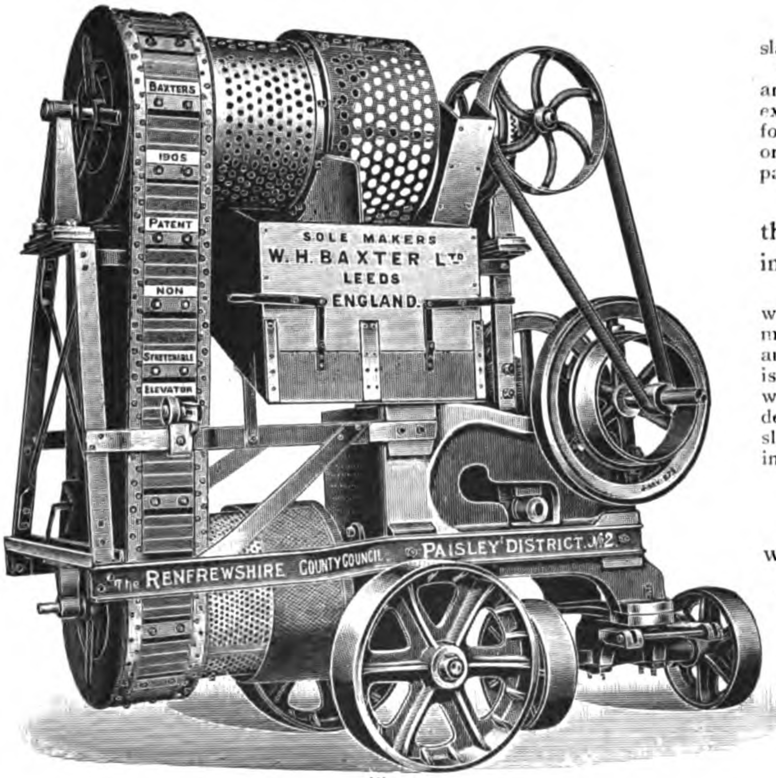


Fig. 19

It has a frictionless lever for the stone-breaker. The bearings are of gun-metal, turned and bored to gauge. The connecting rod, lever and toggle cushions are all of cast-steel. The cubing jaws are in four sections, and bed against the planed surfaces of the moveable jaw and end of the frame, and they are reversible and interchangeable. The broken stone from the stone-breaker passes down the shoot into the lower revolving drum, which has small holes through which the gravel and dust falls. This lower, and the upper drum, are provided in their circumference with openings somewhat smaller than the mouths of the buckets. These openings are of equal pitch with the buckets, and the mouths of the latter completely cover the openings. The broken stone passes out of the lower drum into the buckets and conveyed thence into the upper drum and thence through the screen into the bins seen in fig. 16. At the other end of the screen is a shute to return to the stone breaker any stones that are too large. The breaker, conveyer and screen are all worked from off the same fly-wheel.

Fig. 17 is another view of Marsden's stone-crusher. eight of which have been supplied to the Beunos Ayres Great Southern R., and two to the Imperial Railways of Japan.

Fig. 18 shows the Knapping-motion stone breaker of W. H. Baxter, Ltd., of Leeds, in its fixed form. This has a compound toggle motion for which it is claimed that the support is increased with reduced power and for the Knaponised jaw and the other castings it is claimed that they are superior to those of manganese or other steel less costly. The elevator is jointless and unstretchable so that raising and lowering of the screens to tighten the elevator is not necessary. The stone passes out of the crusher through shute 2 into the lower drum 3 where the sand is sifted out on the right and the gravel on the left. The larger stones are delivered on to the belt of the conveyor 4 and falls into the buckets. They are thereby elevated and put into the upper drum 5 and screened into two sizes and delivered through the shutes 6. What are too large are rejected through 7 and sent back into the stone-breaker.

Fig. 19 is practically the same machine, but portable. Baxter's machines are in use on several British and South American railways.

(To be continued.)

Capstan Lathes in 1908.

In the following article we include, under the name of Capstan Lathes, all lathes having a rotating tool-holder, These may briefly be divided into two classes: the semi-automatic, each of which is attended to by an operator, and the full-automatic, of which one attendant can look after from four to ten machines.

The semi-automatic lathes are of more general interest to the engineering trade, as their application is so very much greater, and they are now found in practically every engineering works of any size.

The full-automatic machines are confined to shops in which a considerable amount of repetition work is done, such as establishments devoted to the manufacture of bicycles, sewing machines, textile machinery, locomotives and ordnance.

The firm of Messrs. Alfred Herbert, Ltd., of Coventry, England, have devoted almost their entire attention to the development of the Capstan Lathe in both its automatic and semi-automatic form, for the last fifteen years, and they now build a very complete line, which it is our purpose to briefly describe.

The firm has two works at Coventry, the head works employing 1,000 men occupied entirely with the production of Capstan Lathes, and the branch works employing 500 men, the latter being devoted exclusively to the manufacture of horizontal and vertical milling machines.

Figure 1 shows the erecting bay, devoted to full-automatic capstan lathes, from which it will be noticed that the machines are built in large numbers at a time

The standard type of full-automatic machine is shown by figure 2, the design being compact and of great rigidity, with large bearing surfaces and ample power to take full advantage of high-speed cutting tools.

Fig. 1.

The operations of advancing, withdrawing and rotating the turret, moving the cross-slide in and out, opening and closing the chuck, and advancing the bar are all performed automatically by cams carried on drums mounted on the lower shaft.

For general work a standard set of cams is supplied, which, without any alteration, enables any article within the capacity of the machine to be produced; this renders the automatic machine suitable for work which does not occur in very large quantities, as the machine is quickly changed over from one piece to another. Where a machine can be kept set up on the same article for very long periods, special cams are fitted to the cam drums, so that the work may be done in the shortest possible time.

As one operator can attend from four to ten automatic machines, the number depending upon the quantities in which the work can be put in hand, the labour cost of the work is naturally exceedingly low.

Turning to the semi-automatic capstan lathes, the most generally useful machine is shown by fig. 3.

This machine is specially designed for making direct from the bar all kinds of bolts, studs, screws, pins, shafts, collars, and lock-nuts, and is offered in two sizes, admitting bars up to 2¼-in. and 3½-in. diameter respectively. A special feature of this lathe is the fact that it is suitable for either long or short work. It is supplied complete with an outfit of tools and accessories that will handle any job within its

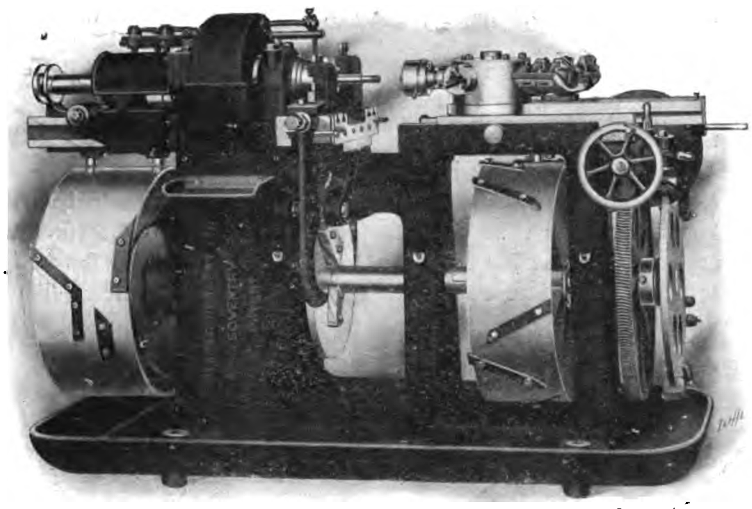


Fig. 2.

capacity, and it is so easy to adjust the tools that it pays to make either one or two articles or a large quantity at each setting.

The work for which this machine is specially designed is that which occurs most generally in all engineering establishments, and there are very few shops where this machine cannot be profitably employed.

The leading feature of the lathe consists in the fact that all reductions in diameter are made at one cut, leaving a true, smooth and parallel job; no finishing cuts are ever taken.

Fig. 3.

The patent roller steady turning tool, by which the heaviest reductions in diameter can be made at a high periphery speed with a coarse feed is shown by fig. 4.

This tool is of quite recent introduction, and is the result of several years' careful experiment, and has effected a most astonishing increase in the production which may be obtained from the lathe.

Before its advent the steadies employed were of the flat or friction type, but it was found that when high speed cutting tools were used the high surface speed of the work, combined with the pressure at the point of contact with the steady, rapidly destroyed the face of the latter, causing bad finish to the work. The limit of production was therefore the speed at which the steady would stand. The roller steady tool, however, entirely removes any friction at the point of contact with the work and places the limit of output with the cutting tool, and will remove metal four times as fast as the flat steady tool.

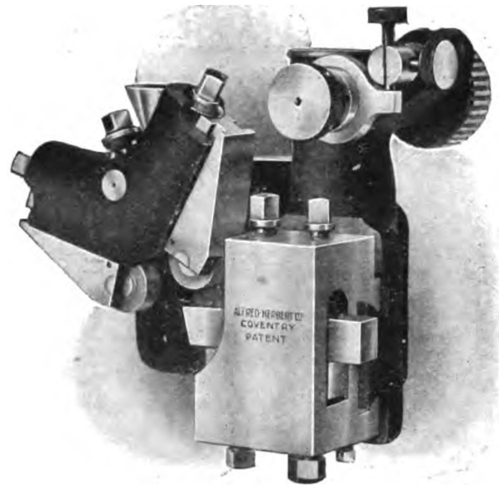


Fig. 4.

The cutter, which is of simple form, is mounted in a steel slide, which can be moved in and out by means of the knurled wheel shown. A very sensitive stop arrangement enables the cutter to be withdrawn from the work and returned any number of times with a certainty of producing exactly the same diameter.

The hard tool steel rollers forming the steadies are supported centrally on their slides so that no amount of pressure can cause them to spring, but only serves to preserve their correct contact with the work.

Fig. 5 shows an actual photograph of a reduction in

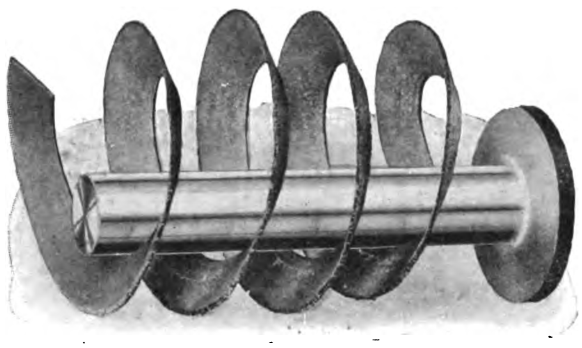


Fig. 5.

diameter made by this tool, the finish produced by one cut being all that could be desired.

Screwing is performed by means of a self-opening diehead, shown in fig. 6.

The dies are produced by milling, and not by master taps. This method of production offers several advantages. It eliminates two sources of error found in dies cut with master taps, namely, the error due to inaccuracy in the lead screw from which the tap is cut, and the error due to distortion in the hardening of the tap.

The thread of the dies is so formed as to provide a very keen cutting edge at the front and a guide portion, like a nut, at the back. This guide portion engages with the threads cut and preserves the correct pitch of the work.

The diehead opens automatically when the travel is retarded.

The hexagon turret lathe shown in fig. 3 is not intended to deal with any work except that made from the bar direct.

For chucking work, that is to say articles machined from castings or forgings, the firm build an entirely distinct type of lathe, which is shown in fig. 7.

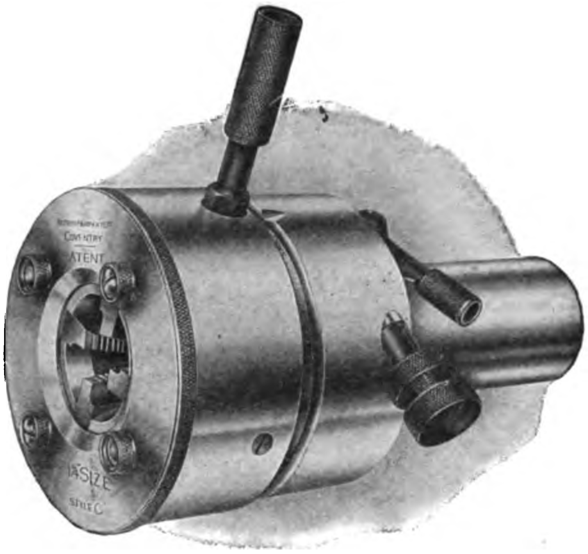


Fig. 6.

It will be noticed that the main difference in the design lies in the fact that the lathe for chuck work is fitted with a

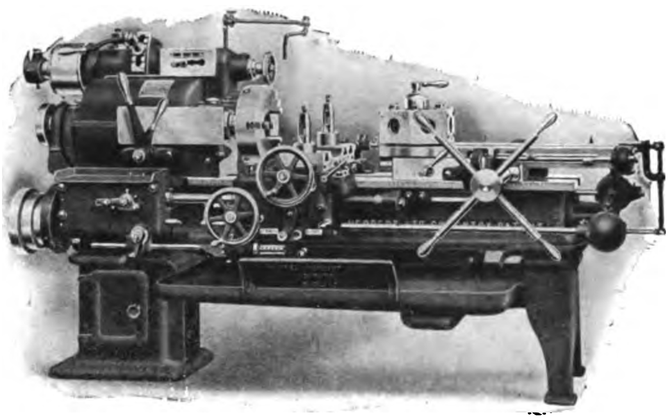


Fig. 7.

saddle in addition to a turret. This difference in design is caused by the variation in chuck work generally occurring in diameter and necessitating a larger amount of cross-transverse than can be accommodated by a machine having a turret only.

In chuck work two operations, such as boring and turning or boring and facing, may frequently proceed simultaneously with great economy in time occupied. These two operations may be most conveniently performed at the same time on machines which are fitted with a saddle in addition to a turret.

The range of machines offered for chuck work is considerably greater than in the case of the machine for bar work, as the articles to be made have a much larger variation in size.

Fig. 8 shows a heavier machine than that just described, and is known as the Combination Turret Lathe. It is suitable for chuck work up to 20-in. diameter by 24-in. long, and within these limits will handle the heaviest and most difficult work.

The machine is shown equipped with a set of tools for producing wrought iron pistons for express passenger locomotives. The piston seen in the chuck is 20-in. diameter and 4-in. wide. The web is of curved outline and there is about $\frac{5}{8}$-in. of metal to remove all over, and a taper hole to be bored and reamed. The outside diameter has to be turned and the grooves for the rings cut in. The work is finished in the actual time of two hours and twenty minutes. The

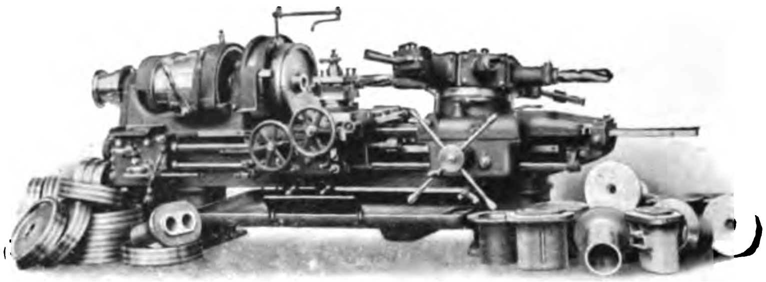


Fig. 8.

curved web is first roughed out with an ordinary turning tool in the square turret and then finished exact to shape with a wide form cutter carried in a holder and bolted to the face of the turret.

The average production of this type of lathe when equipped with suitable tools is four times as great as that of the ordinary lathe, the work being also far more uniform.

Fig. 9 shows some of the capstan lathes in that part of Messrs. Herbert's works which is devoted to the production of chuck work.

It may be pointed out that labour-saving tools of this kind usually give the best results when they are grouped together in a separate department under the charge of a man who is responsible for the quantity and quality of the work produced, and can see that full advantage is taken of properly designed tools and fixtures. The output of a capstan lathe being so

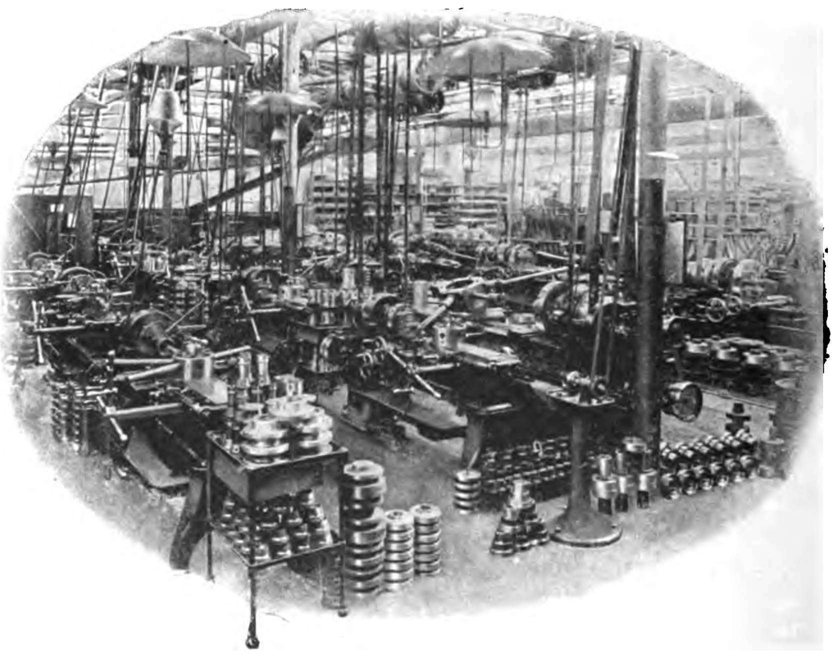
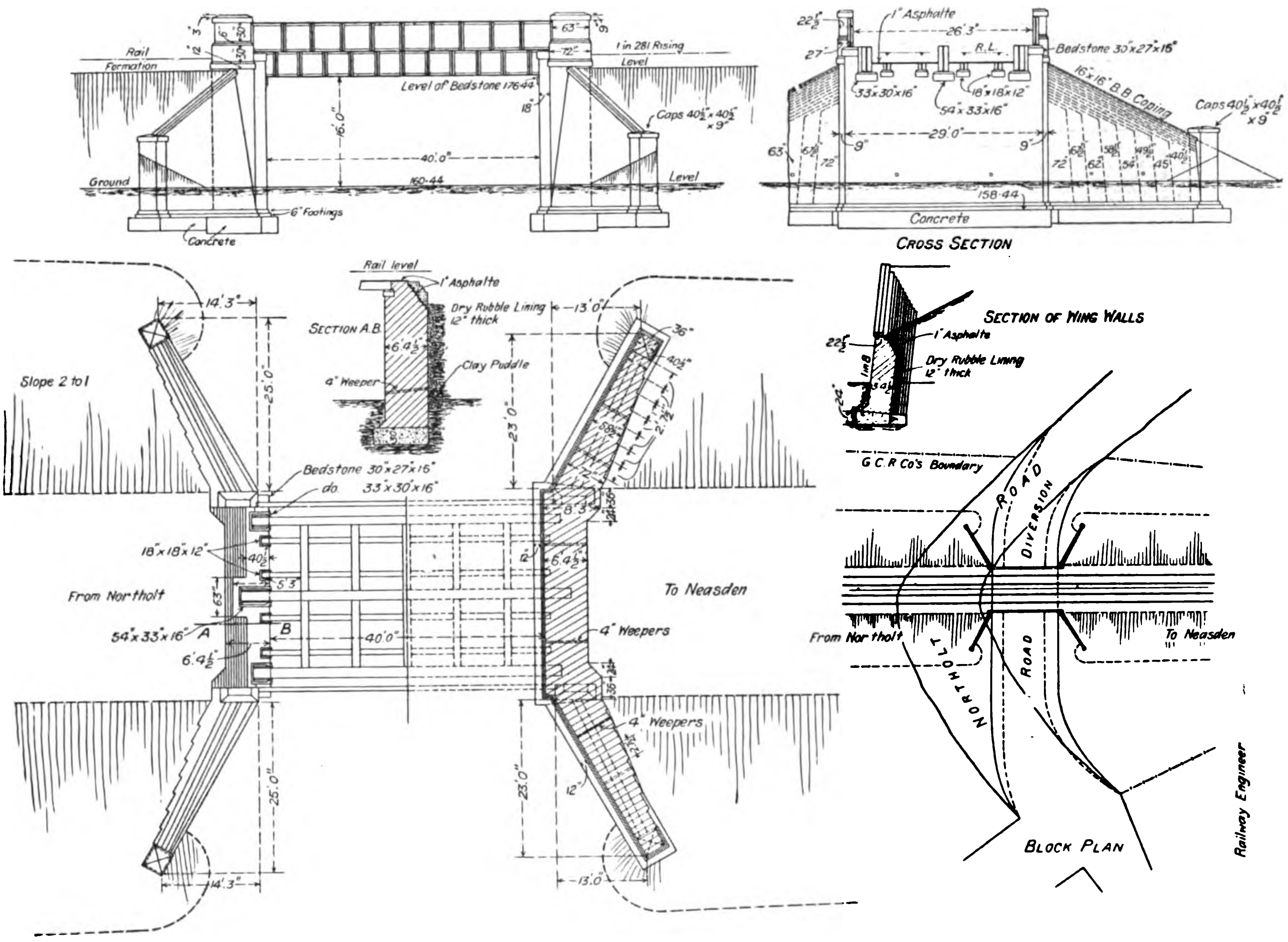


Fig. 9.

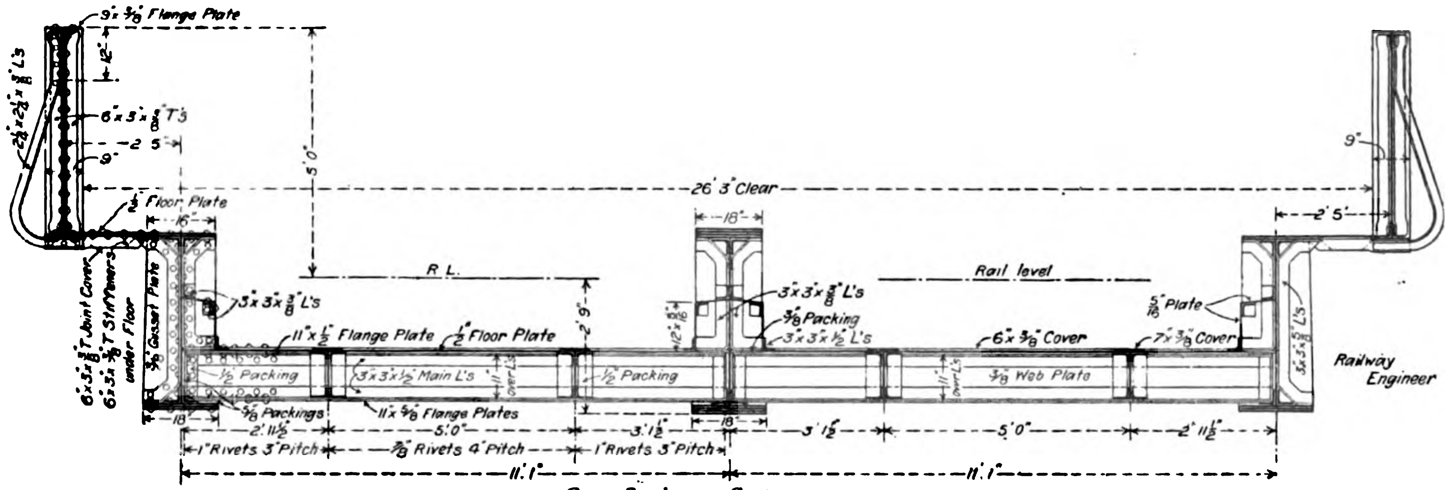
much greater than that of an ordinary lathe it is fairly entitled to a larger share of attention so that the best results may be obtained from its use. If placed amongst ordinary lathes there is always a danger that the capstan lathe will suffer from lack of proper tools that would enable it efficiently to deal with all the work that should fall to its share, and the mere fact of such environment will sometimes cause it to be a disappointment to both purchaser and builder.

Northolt Road Under Bridge, Great Central Railway.

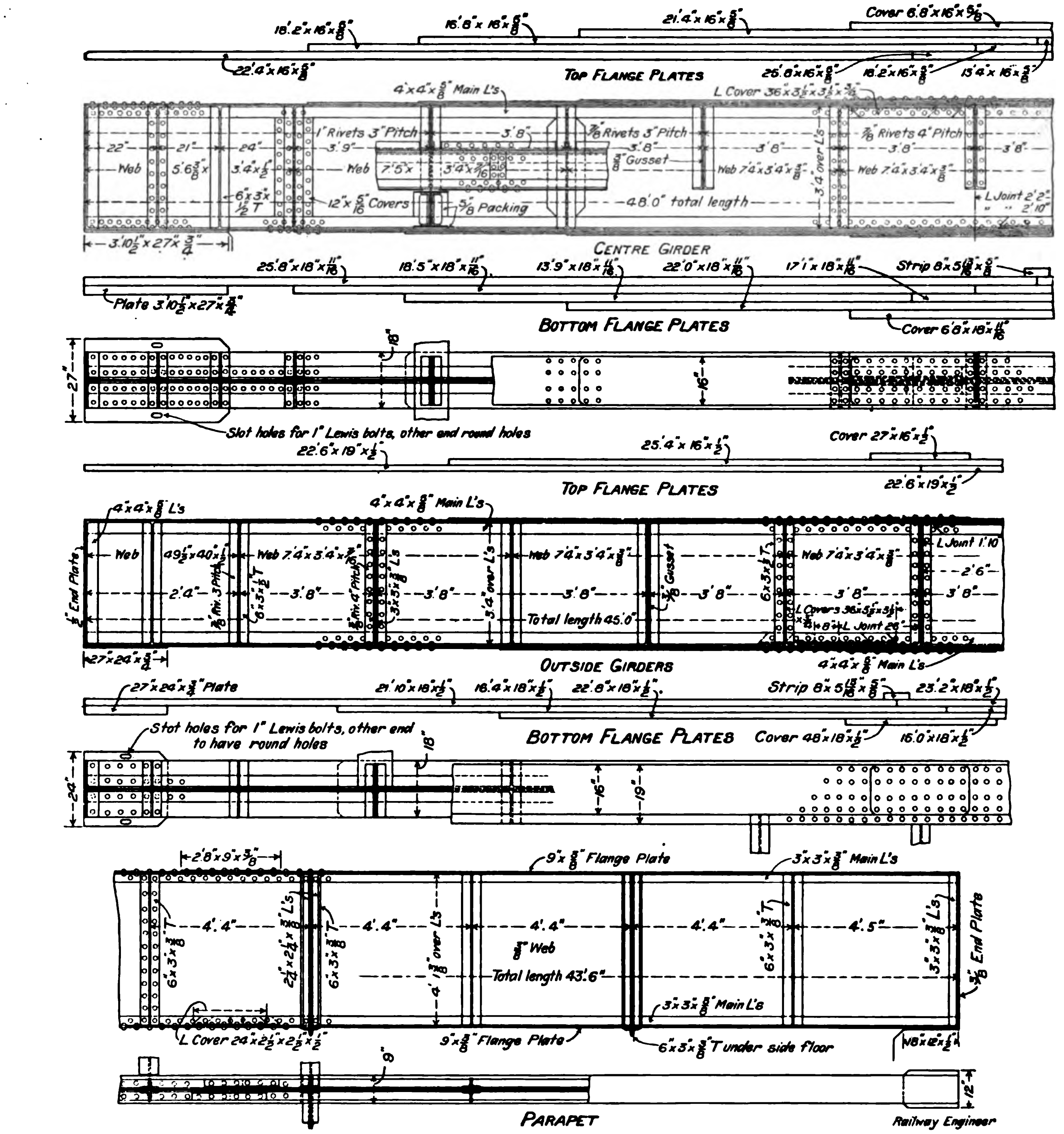
In response to several requests for drawings and particulars of an ordinary railway under bridge over a public road we are able to give the drawings of the bridge carrying the recently constructed railway from Neasden to Northolt, and which is now part of the main line of the Great Central R. In our issue for March, 1906, we gave a full description of this line, and its important bridges and other engineering features



Bridge over Northolt Road at 1 m. 34½ ch. Neasden to Northolt R., Great Central Railway.



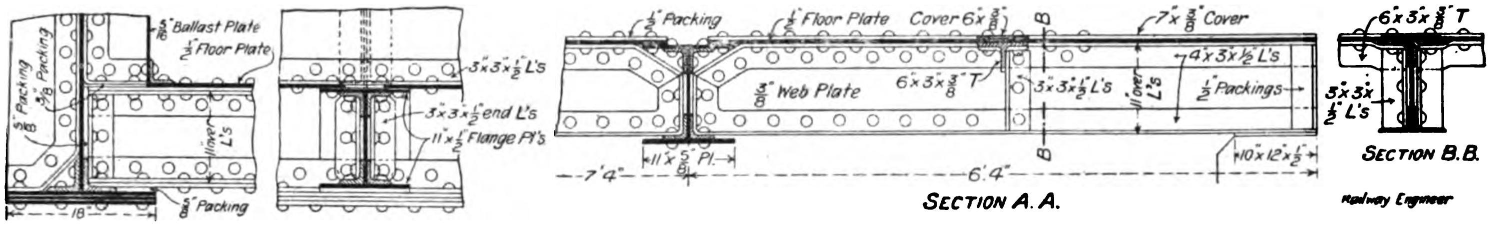
Cross Section at Centre.



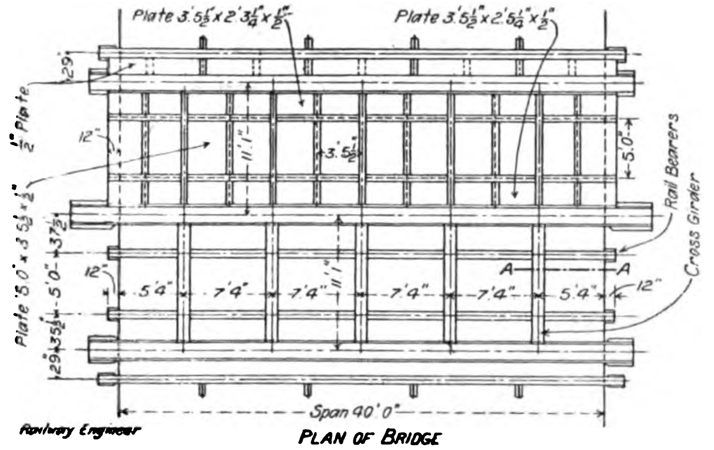
S eelwork of Bridge over Northolt Road at 11 m. 34½ chs., Neasden to Northolt, Great Central Railway.

were illustrated. A very similar bridge to the one we illustrate herewith might and most probably would be required in any 10 miles of railway in this country. This bridge, like the rest of the Neasden-Northolt line, was designed by Mr. C. A. Rowlandson, M.Inst.C.E., chief engineer of the Great Central R. The block plan shows the "road diversion," and that when the railway was constructed the opportunity was seized of doing away—at the expense of the railway company—with a very nasty kink which existed in the Northolt Road.

The girders are of steel, and need little description, as the drawings given are fully dimensioned. They are designed to carry the heaviest modern engines, and have a clear span of 40ft. The new diverted road is quite square with the railway. The rivets in the main and cross girders are ⅞in. diam., 4in. pitch, and those in the parapets, flooring, ballast plates and rail bearers, except where otherwise stated on drawings, are ¾in. diam. and 4in. pitch: in the bearings and where required they are countersunk: all the holes are drilled. The main girders have a permanent camber of 2ins. at the centre and the cross girders a camber ½in. at the centre.



Connection of Gross Girders and Main Girders.



Bridge over Northolt Road at 1 m. 34¼ chs , Neasden to Northolt Railway, Great Central Railway.

Combustion Processes in English Locomotive Fire Boxes.*

(Concluded from page 296.)

The first point investigated was the variation of the products of combustion with varying speeds, weight of train drawn, and gradients. These results for an engine of the "Precursor" class are given in Tables 1 to 6. In the first column the number of the sample is given, in the second the number of cars forming the train, in the third the gradient, in the fourth the speed in miles per hour, determined by observing the ¼-mile posts and stop-watch, in the fifth, sixth, seventh, and eighth the percentage by volume of carbon-dioxide, oxygen, carbon-monoxide, and nitrogen respectively. In the ninth column the ratio of carbon-monoxide to carbon-dioxide, which shows the ratio of the weight of carbon partially burnt to that completely burnt; in the tenth column is the ratio of the carbon-monoxide to carbon-monoxide plus carbon-dioxide, which gives the weight of carbon partially burned compared with the total amount consumed. The last column, multiplied by 100, gives the percentage of the carbon of the fuel lost, due to the formation of carbon-monoxide, which escapes combustion.

TABLE 1.—*Liverpool to Shrewsbury and back to Crewe.*

Sample.	Number of Cars.	Gradient.	Speed. M. per h.	Percentage by Volume. CO_2	O_2	CO	N_2 &c. by diff.	$\frac{CO}{CO_2}$	$\frac{CO}{CO+CO_2}$
1	—	level	60	10·0	7·2	0·5	82·3	0·020	0·020
2	—	rising	45	11·5	4·7	0·7	83·1	0·060	0·056
3	—	—	55-56	13·5	2·1	1·0	83·4	0·074	0·069
4	—	rising	varying	12·2	5·1	1·1	81·6	0·090	0·083
5*	—	—	45	9·3	5·6	2·3	82·8	0·240	0·200
6	—	1 in 687 down	75	16·0	5·1	0·3	78·6	0·020	0·018
7	—	falling	60	13·5	2·0	0·0	84·5	0·000	0·000
8	—	1 in 137 down	60	14·5	2·3	0·2	82·0	0·013	0·013
9	—	1 in 230 down	75	14·1	2·8	0·1	83·0	0·007	0·007

* Fire-door open during sampling.

TABLE 2.—*Crewe to Rugby and back.*

1	10	1 in 176 up	40	14·0	3·0	0·9	82·1	0·064	0·060
2	,,	level	65	11·8	3·9	0·2	84·1	0·017	0·016
3	17	,,	60	13·2	3·6	0·5	82·7	0·037	0·036
4	,,	—	61	11·7	1·3	0·7	86·3	0·060	0·056
5	,,	rising	53	12·5	1·2	2·3	84·0	0·184	0·155
6	14	—	50	12·4	2·8	0·7	84·1	0·056	0·053
7	,,	falling	66	13·8	1·6	0·1	84·5	0·007	0·007
8	,,	1 in 505 up	58	17·1	1·5	0·2	81·2	0·011	0·011

* A six-wheeled coach is counted as one, an eight-wheeled coach as one and a half, a dining-car or sleeping-saloon as two.

TABLE 3.—*Holyhead to Chester.*

1	13	1 in 97 down	60	12·4	5·1	2·1	80·4	0·170	0·145
2	,,	1 in 360-370 up	48	13·9	3·7	0·4	82·0	0·029	0·028
3	,,	1 in 176 up	51	12·1	2·0	1·1	84·8	0·090	0·083
4	,,	1 in 97 up	62	12·4	1·1	0·8	85·7	0·064	0·060
5*	,,	1 in 1527 down	62	9·8	8·2	0·0	82·0	0·000	0·000
6*	,,	1 in 687 down	60·2	6·8	10·2	0·0	81·0	0·000	0·000
7	,,	1 in 100 up	53·0	13·8	0·0	0·5	85·7	0·036	0·034
8	,,	level	53·7	16·1	1·6	0·2	82·1	0·012	0·012
9	,,	level	60	15·1	3·2	0·0	81·7	0·000	0·000

* Fire-door open

TABLE 4.—*Preston to Carlisle and Carlisle to Crewe.*

1	17½	1 in 1042 up	60	15·0	2·0	0·0	83·0	0·000	0·000
2	,,	1 in 104 up	36	13·4	1·8	2·8	82·0	0·209	0·172
3	,,	1 in 75 up	37	15·7	0·2	2·2	81·9	0·141	0·123
4	,,	1 in 75 up	38·3	15·6	0·4	1·8	82·2	0·116	0·103
5	,,	1 in 75 up	37·4	15·1	0·8	1·6	82·5	0·106	0·096
6	12½	1 in 150 up	41·4	15·9	0·1	1·6	82·4	0·100	0·091
7	,,	1 in 100 up	44·0	12·3	5·2	0·0	82·5	0·000	0·000
8	19	1 in 110 up	36·0	13·2	2·5	0·8	83·5	0·060	0·057
9	,,	1 in 142 up	45·0	15·1	1·9	0·7	82·3	0·045	0·044
10	,,	1 in 100 up	60·0	12·8	4·1	0·0	83·1	0·000	0·000

TABLE 5.—*Liverpool to Shrewsbury and back.*

1	17½	1 in 660 down	60·0	5·4	12·2	0·0	82·4	0·000	0·000
2	,,	1 in 2220 up	48·6	14·3	3·7	0·6	81·4	0·041	0·040
3	,,	1 in 411 up	53·0	14·4	0·7	4·2	80·7	0·291	0·226
4	10	1 in 97 up	60·0	10·7	6·6	1·7	81·0	0·158	0·137
5	,,	1 in 281 up	60·0	11·4	1·2	3·8	83·6	0·333	0·250
6	,,	1 in 687 down	69·2	15·8	4·1	0·4	79·7	0·025	0·024
7	,,	—	60·0	15·7	1·1	1·1	82·1	0·070	0·065
8	,,	1 in 137 down	62·0	14·3	3·3	0·4	82·0	0·028	0·027
9	,,	1 in 230 down	75·0	16·3	0·4	0·4	82·9	0·024	0·023
10	,,	1 in 100 down	75·0	15·2	2·1	0·0	82·7	0·000	0·000

TABLE 6.—*Crewe to Rugby and back.*

1	17	1 in 177 up	37·5	12·7	2·7	4·1	80·5	0·324	0·244
2	,,	1 in 318 up	41·0	11·7	3·0	2·2	83·1	0·188	0·165
3	,,	1 in 766 up	54·5	14·1	3·1	2·1	80·7	0·149	0·130
4	,,	1 in 463 down	45·5	10·8	3·8	2·3	83·1	0·213	0·175
5*	,,	1 in 451 up	56·2	6·3	8·6	1·5	83·6	0·238	0·192
6	,,	1 in 330 up	47·3	13·1	1·3	4·1	81·5	0·313	0·238
7	15½	1 in 350 up	39·1	13·0	2·3	3·1	81·6	0·238	0·192
8	13	1 in 517 up	43·9	13·8	3·3	0·4	82·5	0·030	0·028
9	,,	1 in 177 down	68·0	12·5	5·4	0·0	82·1	0·000	0·000

* Fire-door open.

From these results it is evident that the loss due to the formation and escape of carbon-monoxide is greatest at comparatively low speeds, with late cut-off and strong blasts at long intervals as compared with much shorter intervals when running at high speeds, and at speeds of about sixty miles an hour, the quantity of carbon-monoxide in the product of combustion is practically *nil*. Further, in most cases, there was more than sufficient oxygen present to burn the carbon-monoxide completely, and the escape of this from complete combustion is due, in all probability, to the extremely rapid rate at which the gases are swept through the tubes and cooled down, so that the oxygen and carbon-monoxide had no time to combine. The presence of carbon-monoxide in the products of combustion at low speeds is due to the intermittent character of the air-supply. The escape of the exhaust steam up the funnel takes place in a series of "puffs," and the interval between each "puff" varies with the speed of the train, hence the products of combustion are left in contact with the strongly heated fuel for a time interval depending upon the rapidity with which the "puffs" follow each other, and so partial reduction of the carbon-dioxide to monoxide takes place. Then, at the next "puff," the gases are drawn out of the fire-box, along the fire-tubes and into the smoke-box before the complete combustion of the carbon-monoxide has time to take place. The effect of the gradient is that of reducing the speed of the train, thereby increasing the length of time between each "puff"; hence the time during which the products of combustion remain in contact with the incandescent fuel is also increased. The heavier the train the greater is this slowing down when ascending a gradient; hence the proportion of carbon-monoxide which escapes combustion is greatest when the engine is working heavily, *e.g.*, drawing a heavy train up a steep gradient.

The vacuum in the smoke-box was next measured. The sampling-pipe was connected with a U-shaped gauge, containing coloured water, at the back of which was a graduated

*Abstract of a paper by Dr. F. J. Brislee, read before the Institution of Mechanical Engineers.

glass scale. The gauge was fitted with a glass tap so that it could be shut off during sampling and when not in use The vacuum measured was the mean vacuum in the section of the smoke-box from which the samples were drawn. The first measurements showed that it varied with the time of cut-off by the slide-valve, as well as with the extent to which the regulator was opened. It depended also upon the resistance of the fire to the passage of the air. The vacuum reached, under certain conditions, was 10 to 12in. of water, but on the average it was 5-7in. of water, the higher figures being only very occasionally reached, and were never steady and were not maintained for more than a few minutes. When the fire-door was opened for firing the vacuum sank from 5-7in. to 1-2 in., the air entering freely through the open fire-door. At high speeds the vacuum was smaller, as a rule about 3-5in., but steady, and then the air-supply approximated to a steady current, and combustion was complete, the amount of carbon-monoxide being very small, or *nil*. The results are given in Tables 7, 8 and 9, the data being the same as in the preceding tables, except that in the last column the partial vacuum in the smoke-box, measured in inches of water, is given.

From these tables it will be seen that the most efficient combustion takes place when the vacuum is relatively small and the speed high. The higher vacua were never steady, but were obtaned in a series of jerks. The conditions necessary for the most effective combustion require that the current

TABLE 7.—*Preston to Carlisle and back.*

Sample.	Number of Cars.	Gradient.	Speed. M. per h.	Percentage by Volume. CO_2	O_2	CO	N_2 &c. by diff.	$\frac{CO}{CO_2}$	$\frac{CO}{CO+CO_2}$	Vacuum, smoke-box. in.
1	18	1 in 1199 up	61	16·3	0·2	1·6	81·9	0·100	0·089	7 5
2	9	1 in 75 up	64·3	16·1	1·1	0·7	82·1	0·043	0·040	7·5
3	,,	1 in 75 up	42·8	13·6	3·0	1·6	81·8	0·117	0·105	8 0
4	,,	1 in 125 down	75·0	15·0	1·0	1·0	83·0	0·066	0 062	4·1
5	12½	1 in 184 up	42·8	13·5	0·0	2·2	84·3	0·163	0·140	6 0
6	,,	1 in 186 up	51·4	15·0	1·6	2·2	81·2	0·147	0·128	5·0
7	,,	1 in 125 up	42·0	15·8	0·0	1·0	83·2	0·063	0·060	5 9
8	,,	1 in 104 down	69·2	15 9	2·8	0·2	81·1	0·012	0·012	6·4
9*	,,	1 in 90 up	22	11·6	3·6	0·0	81·8	0·000	0·000	4·9
				*Starting.						
TABLE 8.—*London to Liverpool.*										
1	15	1 in 341 up	54·5	15·5	0·0	4·0	80·5	0·260	0·205	8·8
2	,,	1 in 330 up	50	14·4	2·2	1·9	81·5	0·132	0·116	5·9
3	,,	1 in 384 up	53	15·1	0·7	1·5	82·7	0·100	0·090	5 8
4	,,	1 in 330 up	60	15·7	1·8	0 2	82·3	0·013	0·012	5·8
5	,,	1 in 406 up	60	16·6	0·8	0·0	82·6	0 000	0·000	5 8
6	,,	1 in 200 up	50	14·9	3·7	0·0	81·4	0·000	0·000	5 8
7	,,	1 in 505 up	58	13 3	4·1	0·2	82·4	0·015	0·015	5·8
8	,,	1 in 391 up	60	13·9	3·6	0·7	81·8	0·050	0·018	5·8
9	,,	1 in 101 up	58	14·4	3·9	0·0	8.·7	0·000	0·000	5·5
TABLE 9.—*Crewe to London.*										
1	17½	1 in 177 up	50	15·3	0·6	2·1	82·0	0·137	0·120	5·2
2	,,	1 in 320 up	64·3	16·2	0·7	1·3	81·8	0·080	0·074	5·7
3	,,	1 in 321 up	57·1	14·0	3·6	0 9	81·5	0·064	0·060	5·4
4	,,	1 in 320 up	51·4	15·1	0·6	1·7	82·6	0·113	0·101	5 7
5	19	1 in 354 up]	45·0	14·7	0·7	2·1	82·5	0·142	0·128	6·9
6	,,	1 in 320 up	53·7	14·2	0·9	3·0	81·9	0·211	0 174	5·9
7	,,	1 in 410 up	62·0	12·4	0·6	4·2	82·8	0·338	0·253	6·4
8	,,	1 in 660 up	58·1	12 7	3·2	1·2	82·9	0·094	0·086	6·4
9	,,	1 in 333 up	55·4	15·0	1·1	3·7	80 2	0·246	0·200	6·2
10	,,	1 in 333 up	47·3	14·6	0·9	2·5	82·0	0·171	0·146	6·0

of air supplied to the fire should be a steady current, and the amount sufficient to render the velocity of combustion great enough for the production of the necessary steam. The employment of the exhaust steam to induce the air-supply is only efficient at high speeds, when the "puffs" follow in extremely rapid succession, so maintaining a steady partial vacuum in the smoke-box, while the air is pushed in through the ash-pan dampers and thence through the fire at a moderately high and fairly constant pressure, due to the passage of the engine through the air. When the thickness of the fire is considerable and the air-supply is intermittent, as when the steam-blast is employed and at low speeds, the tendency for the carbon-dioxide to be reduced to carbon-monoxide is greatly increased; hence *a priori* one would expect a much smaller loss of carbon, due to the formation of carbon-monoxide, in an engine with a thin fire than in one having a deep fire. This point was next investigated. The engine employed was a L. and North-Western R. locomotive of the "Experiment" class. In this class of locomotive the fire-box is only about one-half as deep as in the "Precursor" class, but considerably larger in other directions. This locomotive was fitted up with the same sampling apparatus and vacuum-gauge as in the previous case. The runs selected were nearly all on the Carlisle route, and include all the heaviest, long, non-stop runs on the L. and North-Western R. The loads taken were, as a rule, very heavy and the average speeds high. Further, this class of engine was specially designed with a view to working heavy passenger traffic on the London to Carlisle route. The road from Crewe to Carlisle is specially heavy, the gradients being all fairly steep, the track being almost continually uphill from Preston to Shap Summit, fig. 4. The first run was from Liverpool to Shrewsbury and back, in which the load was by no means heavy and the speed high. The results are given in Table 10.

TABLE 10.—*Lime Street, Liverpool to Shrewsbury.* **12.0** *noon ex Lime Street.*

Sample.	No. of Cars.	Gradient.	Speed, m.p.h.	Carbon-Dioxide.	Oxygen.	Carbon-Monoxide.	Nitrogen, N_2 &c. by diff.	$\frac{CO}{CO_2}$	$\frac{CO}{CO+CO_2}$	Pressure, Ash Pan,* inches.	Vacuum, Smoke-Box, inches.
1	18	1 in 230 down	60	14·7	1·4	1·0	83 1	0·068	0·063	1·8	3·2
2	,,	1 in 158 up	36·7	14·7	1·3	1·5	82·5	0·102	0·092	0·7	5·7
3	,,	1 in 616 up	51·5	11·7	1·9	1·7	84·7	0·145	0·127	1·5	4·3
4	10	1 in 110 up	53·0	14·8	0·4	0·8	84·0	0·054	0·051	1·4	4·6
5	,,	1 in 155 up	63·0	12·8	2·1	1·2	83·9	0·093	0·086	1·9	3·4
6	,,	1 in 208 down	51·4	14·4	0·7	1·1	83·8	0·076	0·071	1·3	5·4
7	,,	1 in 1,130 up	54·5	15·1	1·1	0·5	83·4	0·033	0·032	1·4	5·3
8	,,	1 in 150 down	75·0	16·0	0·7	0·9	81·4	0·056	0·053	2·6	4·6
9	,,	1 in 2,223 down	51·4	13·2	1·0	0·4	85·4	0·030	0·029	1·3	3·5

* The pressure in the ash-pan was calculated from the velocity, a speed of 68 ft. per second being taken as causing a pressure of 1 inch of water.

If these results are compared with those in Table 5 it will be seen that the percentage of carbon-monoxide is not so high with the "Experiment" class as with the "Precursor" class. The highest in Table 5 being Nos. 3 and 5, in which the carbon-monoxide reaches 4·2 and 3·8 per cent. respectively, the highest in Table 10 being No. 3, which is 1·7 per cent. of carbon-monoxide. The partial vacuum in the smoke-box is also much less in the "Experiment" class than in the "Precursor" class, due to the decreased thickness of the fire, which offered less resistance to the passage of the air and also to the increase in area of the grate. The vacuum in the smoke-box in this class was about 3-5in. of water, higher figures only being very occasionally reached. The next runs were all on the Crewe to Carlisle route, and the results are given in Tables 11 to 15.

The figures in these tables show a very great diminution in the percentage of carbon-monoxide, even in the highest it is less than 2·0 per cent., while the carbon-dioxide, in the majority of instances, is high. The "gas-producer" action

TABLE 11.—*Preston to Carlisle and Carlisle to Crewe.* **11.0** *a.m. ex Preston.* **4.12** *p.m ex Carlisle.*

1	10	1 in 131 up	47·3	14·3	0·0	1·1	84·6	0·076	0·071	1·1	6·0
2	,,	1 in 75 up	60·0	13·9	0·4	0·4	85·3	0·030	0·029	1·8	4·8
3	,,	1 in 75 up	45·0	13 5	0·2	1·5	84 8	0·111	0·100	1·0	5·6
4	,,	1 in 75 up	33·3	9 7	8·6	0·4	81·3	0·041	0·039	0·5	5·6
5	,,	1 in 125 up	45·0	14·6	2 8	0 0	82·6	0·000	0·000	1·0	4·6
6	,,	1 in 181 up	37·5	15·6	0·9	0·5	83·0	0·032	0·031	0·7	4·8
7	,,	1 in 142 up	37·5	14·8	2·1	1·0	82·1	0·067	0·063	0·7	4·8
8	17½	1 in 110 up	45·0	15 7	2·1	0·0	82·2	0·000	0·000	1·0	5·9
9	,,	1 in 104 up	50·0	14·2	4·0	0·0	81·8	0·000	0·000	1·2	6·4
10	,,	1 in 135 up	47 3	12·2	5·7	0·0	82·1	0·000	0·000	1·1	9·2

TABLE 12.—*Crewe to Carlisle.* **1 12** *p.m. ex Crewe. Non-stop.*

1	11	1 in 128 up	60	16·0	1·4	0·4	82·2	0·025	0·024	1·8	5·3
2	,,	1 in 104 up	5.·4	14·0	0·9	0·0	85·1	0·000	0·000	1·3	4·8
3	,,	1 in 101 down	72·0	15 9	0·7	0·0	83·4	0·000	0·000	2·5	5·6
4	,,	1 in 134 up	53·7	15·3	1·7	0·0	83·0	0·000	0·000	1·2	3·5
5	,,	1 in 213 up	39·1	14·7	1·7	0·7	82·9	0·017	0·015	0·7	5·4
6	,,	1 in 75 up	47·3	13·3	3·8	0·4	82·5	0·030	0·029	1·1	5·1
7	,,	1 in 75 up	31·0	14·5	3·0	0·7	81·8	0·048	0·046	0·5	5·6
8	,,	1 in 75 up	27·2	13·8	1·9	0·8	83·5	0·058	0·055	0·3	5·9
9	,,	1 in 125 down	73·5	16·0	1·1	0·0	82·0	0·000	0·000	2·6	2·4
10	,,	1 in 184 down	77·0	16·4	1·5	0·5	81·6	0·030	0·029	2·9	2·8

TABLE 13.—*Crewe to Carlisle.* **12.32** *p.m. ex Crewe.*

1	9	1 in 470 up	53·0	1 ·5	5·0	0·0	81·5	0·000	0·000	1·3	6 1
2	,,	1 in 184 down	72·0	15·0	4·1	0 0	80·9	0·000	0·000	2·2	5·9
3	13	1 in 193 up	50	14·1	3 0	0·5	82·4	0·035	0·034	1·2	5·9
4	,,	1 in 134 up	31·6	14·5	2 9	0·5	82·1	0·034	0·033	0·5	5·4
5	,,	1 in 131 up	32·1	13·0	5·0	0·0	82·0	0·000	0·000	0·4	5·4
6	,,	1 in 75 up	30 0	11·2	7·3	1·0	80·5	0·089	0·082	0·3	6·4
7	,,	1 in 75 up	33·3	9·6	8·6	0·4	81·4	0·041	0·040	0·3	6·4
8	,,	1 in 75 up	31·0	10·0	8·0	0·8	81·2	0·080	0·074	0·3	6·4
9	,,	1 in 125 down	69·2	10·4	8·1	0·0	81·5	0·000	0·000	1·3	3·8
10	,,	1 in 172 down	72·0	12·0	5·1	0·0	82·9	0·000	0·000	2·2	3·8

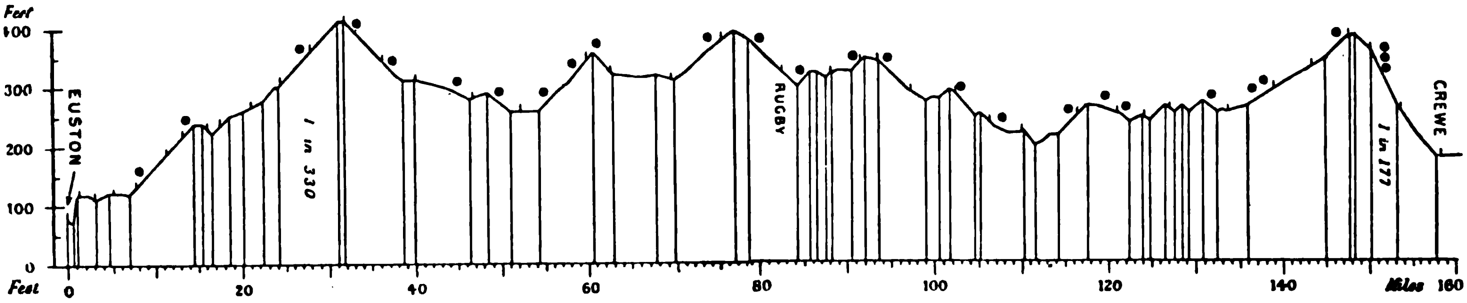
TABLE 14.—*Crewe to Carlisle.* **11.22** *p.m. ex Crewe.*

1	20½	1 in 132 up	50·0	13·8	5·0	0 5	80·7	0·036	0 035	1·2	5·8
2	,,	1 in 100 up	27·0	11 5	6·8	0 4	81·3	0·035	0·033	0·3	5·4
3	,,	1 in 193 up	45·0	10·2	7·4	0·4	82·0	0·039	0·038	1·0	5·8
4	,,	1 in 120 up	32·5	9·7	8·0	0·0	82·3	0·000	0·000	0·4	6·4
5	,,	1 in 100 up	30 0	9·7	8·8	0·0	81·5	0·000	0·000	0·3	5·8
6	,,	1 in 75 up	16·2	9·1	9·5	0·9	80 5	0·098	0·091	0·1	4·8
7	,,	1 in 75 up	30·0	12·0	6·3	0·0	8.·7	0·000	0·000	0 3	5·8
8	,,	1 in 75 up	26·4	11·2	6 6	0 6	81·6	0·0 3	0 051	0·2	5·2
9	,,	1 in 229 down	75·0	13·6	3·9	0·9	81·6	0·066	0·062	2·3	4·2

TABLE 15.—*Crewe to Carlisle and back.* 9.25 *a.m. ex Crewe.* 4.12 *p m. ex Carlisle.*

1	18½	1 in 1199 up	56·2	15·5	1·6	0·7	82·2	0·015	0·014	1·5	4·0
2	„	1 in 175 up	34·0	14·4	3·6	0·9	81·1	0·062	0·060	0·5	4·6
3	„	1 in 120 up	31·5	15·1	1·6	0·8	82·5	0·053	0·050	0·3	4·8
4	„	1 in 75 up	31·0	13·6	3 7	0·9	81·8	0·066	0·062	0·3	5·4
5	„	1 in 75 up	31·0	12·0	4·7	0·9	82·4	0 073	0·069	0·3	5·4
6	„	1 in 75 up	28·1	11·4	5·2	0 9	82·5	0·079	0·073	0 3	5·4
7	16½	1 in 125 up	38·3	14·3	2·3	1·0	82·4	0·070	0 065	0 6	4·6
8	„	1 in 100 up	39·1	15·0	2·4	0 8	81·8	0·0 3	0·051	0·7	4·6
9	„	1 in 175 down	75·0	12·9	2·1	1·1	83·9	0 085	0·079	2·6	1·0
10	19	1 in 115 up	46·1	13·7	2·3	1·7	82 3	0·131	0·110	1·0	4·9

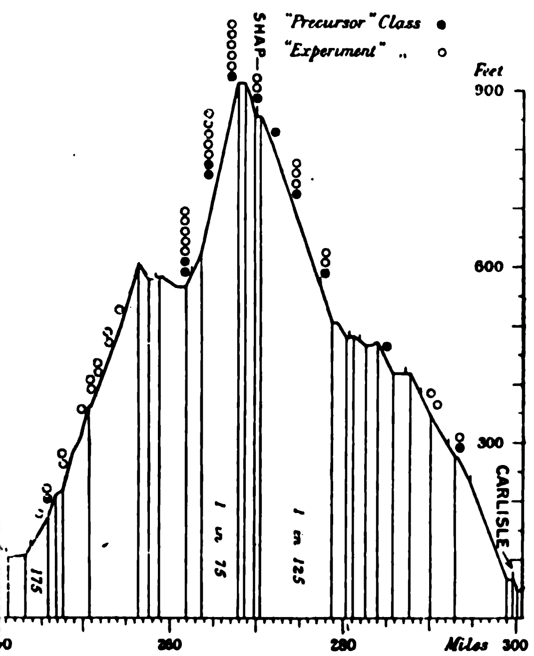
excessive, as comparatively little smoke is emitted by a locomotive when running. The loss of solid fuel thrown out by the steam-blast through the funnel is extremely difficult of estimation, but is considerable in amount. The heat carried off in the products of combustion is another source of loss of fuel, but one of the most difficult of remedy in a locomotive, where space is limited, and where increase of weight beyond



of the fire-box, resulting in the partial reduction of the carbon-dioxide to monoxide is very greatly reduced, as the results show, by reducing the depths of the fire. The effects of heavy working when the full pressure of the boiler is on the cylinders, and the induced draught fierce and intermittent, are especially noticeable in Table 14. This train was practically the very heaviest train running on the system, and demanded the full power of the engine. The rapid passage of the air through the thinner fire resulted in holes being made in the fire by the "jerky" steam-blast, and consequently a large amount of air was drawn through the fire, which had no time to come into contact with the fuel, owing to the rapidity of its passage. The passage of so large an amount of excess air resulted in a considerable lowering of the temperature.

The results in the other Tables show a similar increase in the amount of oxygen when the engine was working heavily. Comparing the results for the "Experiment" with those for the "Precursor" class, the advantage of employ-

Showing positions of Stations and Places where samples of Gases were taken marked thus:—



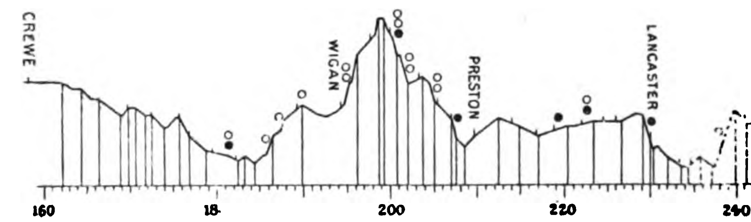


Fig. 4.

ing a thinner fire is manifest, so far as efficient combustion is concerned. At the same time, it is evident that a greater amount of judgment in firing is required, in order to prevent the fire breaking into holes and an unduly large excess of air being drawn through the fire, thereby reducing the temperature, and seriously impairing the steam-raising power of the engine. The presence of the carbon-monoxide in the products of combustion, together with excess oxygen, may be due to either the cooling of the gases before the combustion was complete, or to incomplete mixing.

Considering all the drawbacks of the method of supplying the air to the fire-box, the results for both classes of engines show a very great efficiency, and compare very well with stationary and marine boilers, employing either natural or forced draught. The above results only take account of the carbon lost as carbon-monoxide, the other means of loss of fuel are:—

(1) Loss of carbon as smoke.

(2) Loss of unburnt hydrocarbons.

(3) Loss of solid fuel as fragments thrown out by the steam-blast.

At the stage of the combustion when the samples were taken, that is, after the smoke had cleared, the amount of unburnt hydrocarbons was *nil*, only very slight traces being found in the samples. The loss of carbon as smoke was not

certain limits is undesirable.

The figures in the foregoing tables represent the combustion taking place in first-class locomotive practice and on express trains of high average speeds. The loss due to the formation and escape of carbon-monoxide must necessarily be greater with low-speed trains, owing to the intermittent character of the air-supply.

The employment of a suitable forced draught, by means of which the air-supply would be under control, should do much to reduce the loss of solid fuel, thereby removing a source of danger and also doing away with the dependence of the air-supply upon the speed of the engine.

The Trackless Trolley.

CONSIDERABLE interest has of late been awakened in the question of railless traction—the propulsion of vehicles by electrical power from an overhead equipment without the necessity for the vehicles to travel on rails with the accompanying more or less expensive roadway, with passing loops, etc. The cost of tramway construction on the usual method, together with equipment, even when carried out by municipalities who are able to borrow money at lower rates than private corporations, varies from £10,500 to £46,000 per mile of route, and the average of the whole is £23,500. In

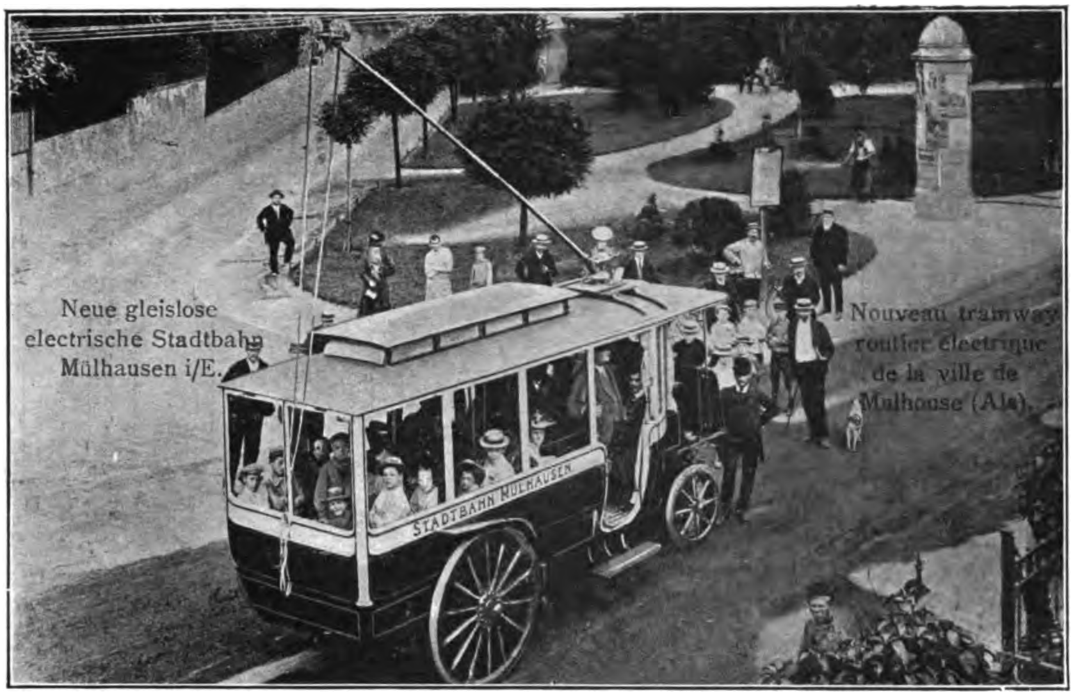


Fig. 1.

this average is not included the London County Council tramways, as, being on the conduit system, their cost is so much higher. Much of this expense is due to permanent way, but a deal is due to preliminary expenses. But railless traction does not require any permanent way, nor does it come within the requirements of the Railways, Tramway or Light Railway Acts. The average cost is therefore put down at from £2,000 to £14,000 per route mile. It is estimated that a line of railless traction to do a business equal to the average of all British tramways would cost about £8,000 per route mile for construction and equipment, and in this is included 10 per cent. for contingencies, which should be sufficient for the preliminary expenses.

The cost is not only less, but the profit of receipts over expenses goes much further. The average profit, after making all deductions, of all the tramways owned by city and town authorities averages slightly over one-halfpenny per car-mile. To make a proper calculation let it be assumed that there are two systems—one a tramway of the usual type and one of railless traction. Each operates 20 cars and does 480,000 car-miles per annum, and each makes a net profit of one-halfpenny per car-mile. If the tramway has cost £75,000 it would only make a profit of $1\frac{1}{3}$ per cent. Whereas if the cost of the raillesss traction is put down at as high a figure as £25,000 the profit of one-halfpenny per car-mile would be equal to 4 per cent.

Then there is the advantage of quicker construction. Given a power station already available, all that is required for railless traction, beyond the cars, is the fixing of the overhead equipment. There are no tiresome delays in opening up the road, laying the track, bonding the rails and pitching the road, and, consequently, capital is remunerative at an earlier date.

Cars can pass each other at any point on the road and a faster car can overtake and pass a slower, such as a passenger-carrying-car passing a goods-wagon.

Hitherto British companies have not done much in this matter, but the Railless Electrical Traction Co., Ltd., who have acquired the patent rights of Max Schiemann and Co., have their hands full just now of schemes for its adoption. The Dundee Corporation have submitted to the Board of Trade for approval a scheme for feeding their tramway system, and the Manchester Corporation are formulating something similar from their tram terminus in Palatine Road through Northenden to Sale, for which they have powers to lay a tramway. A railless tramway is proposed from the outskirts of Dublin to Bray.

The general appearance of the car used on the eight installations on the Continent may be judged from the illustrations. Double decked cars are not employed, trailers being preferred. It is, however, proposed to use double decked cars in this

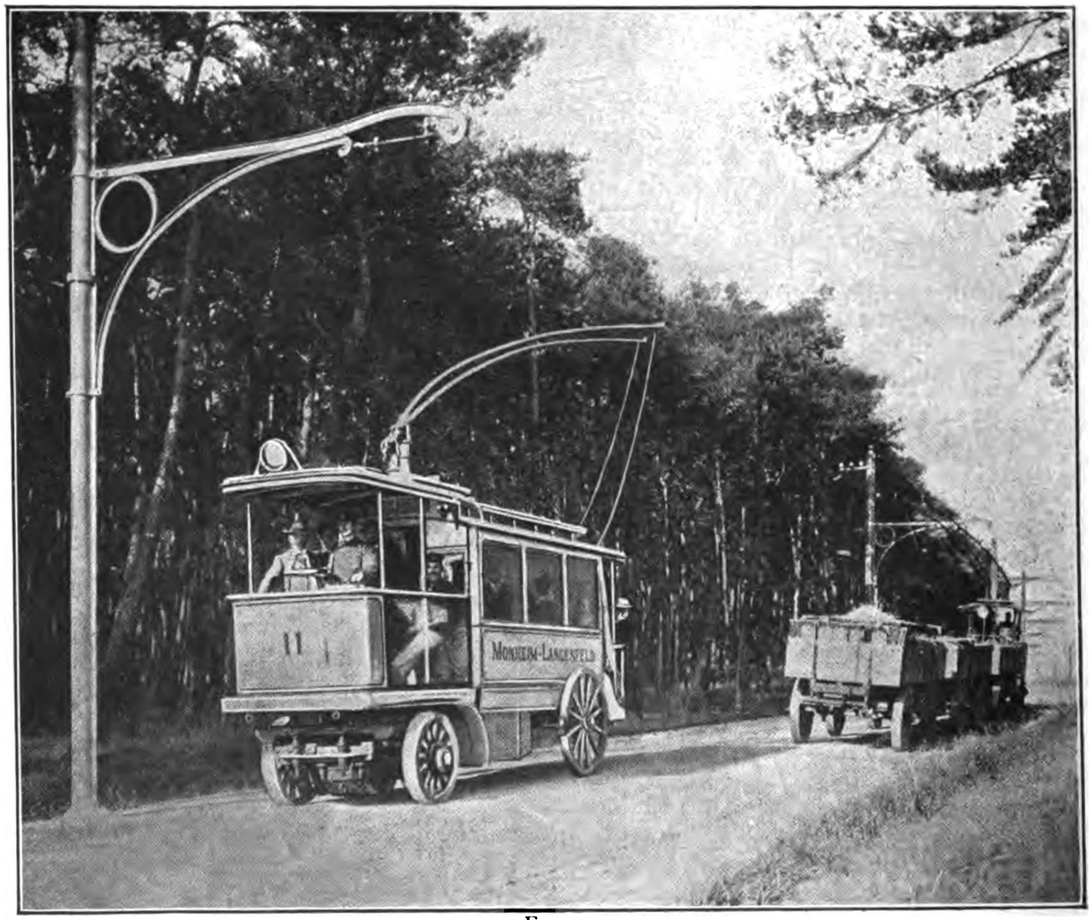


Fig. 2.

country. The car illustrated is at Mulhausen, in Alsace, and ascends a gradient of 1 in 12 with ease, and can attain a speed of 12 miles per hour on the level. The trolley arm is constructed for a lateral deviation of 10ft. on either side of the wires, so that on a road 20ft. wide between the kerb, and the wires carried in the centre, full command of the whole width of the road is given.

In fig. 2 a passenger car is seen crossing a goods train going in the opposite direction. When two cars or trains meet like this they pass each other's trolley boom by one man drawing down his trolley. This illustration shows the double pole, but this has been replaced by a single pole as seen in fig. 1.

Our purpose now is to draw the attention of tramway and railway companies to the new system as an adjunct to their present roads. Some companies, *e.g.*, the L. and North-Western, Great Western, North-Eastern and Great Eastern, have motor-'bus and van services to link up outlying towns and villages to the railway, but they do not claim that their experience with the petrol motor has been a success. We consider that railless traction would give better results and would lead to more being done by other companies in the way of feeders for their railways. There are innumerable roads in our mind, as for instance between Derby and Ashbourne, and along the Solway Coast from Dumfries to Kirkcudbright, through Kirkbean, Dalbeattie and Auchencairn, where such facilities would not only bring profit from existing traffic now conveyed in carriers' carts and private vehicles, but increased and improved facilities would bring more local traffic and attract visitors. It should be borne in mind, too, that the provision of such communication by railway companies will anticipate any applications for light railways. Whilst the law is as it now exists the provision of light railways in any district is remote, but the law is sure to be amended sooner or later. It will, of course, be necessary for railway companies to obtain leave to run the overhead equipment, but in many country districts they would be welcomed. They might, too, as in Germany and America, supply light to the roads and even houses *en route*. A power station is also necessary, unless there be a local one available. But this is not such an expensive item as it was, as an engine of 50 H.P. will now supply power at as low a cost per unit as was possible by a large station ten or so years ago.

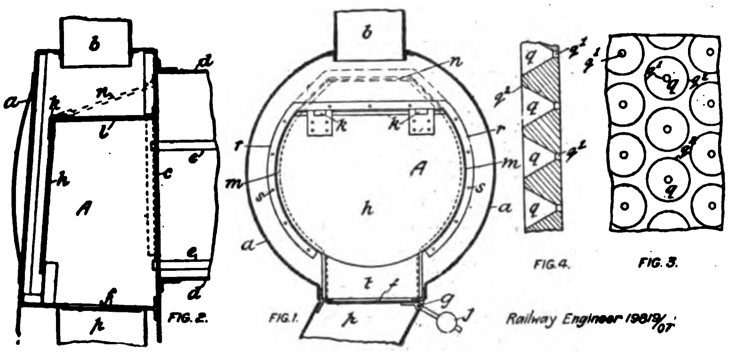
Taking every feature into consideration there appears to be a fine field for railless traction in Great Britain, and the results of the enquiries made by Dundee, Manchester and in Ireland will be awaited with interest.

Recent Patents Relating to Railways.

These abridgments of recently published specifications are specially compiled for this review by Messrs. Wheatley and Mackenzie, Chartered Patent Agents, 40, Chancery Lane, W.C., from whom copies of specifications can be obtained at an uniform price of 8*d*. each.

Spark Arresters. *19,819. 4th September, 1907. W. Stokeld, 49, Hendon Valley Road, Sunderland, and J. Black, 9, Claremont Terrace, Newcastle-on-Tyne.*

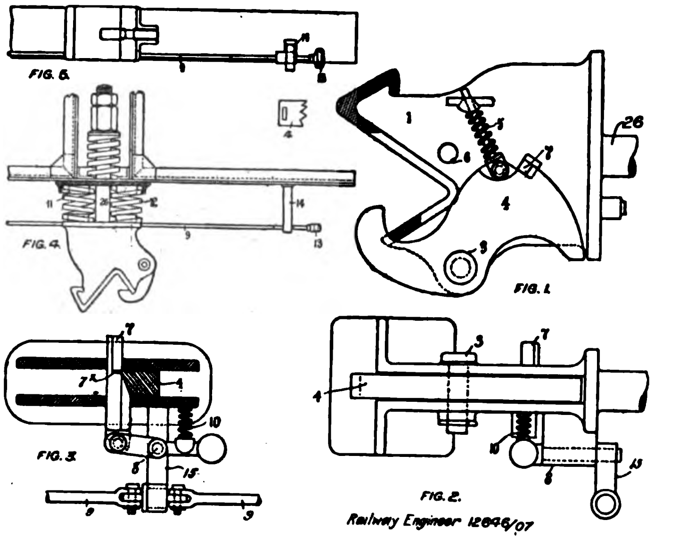
This spark arrester, which is applicable to locomotives and other horizontal multitubular boilers, is made of plain or corrugated plates and shaped or bent so as to keep well away from the ends of the tubes, but is in contact with the tube plate at the top and sides and clear of the tubes *c*, so that all the smoke issuing from the chimney *b* of the locomotive must first pass through the arrester. It may rest on the bottom of the smoke box or be kept clear of the bottom, and the front part is preferably hinged to provide access to the tubes. The plates forming the arrester are perforated with small holes *q* spaced closely together over the whole of the exposed surface, that is to say, the front *h*, top *l*, and sides *m*. These holes are an improved shape, namely, of small diameter q^1 on the inside of the plate, which diameter is retained for a short distance into the plate, and is then splayed out to a comparatively large diameter q^2. The bottom of the smoke box is provided with a hinged door or flap *f* hinged at *g* and opening downwards through which the small cinders that are caught in the arrester are precipitated into a spout *p*, and delivered on the track or other place. Instead of the door being on the bottom of the smoke box, the spout may open into the smoke box, and the door or flap placed on the bottom end of the spout. The door or flap is made to open automatically when a certain



quantity of cinders has accumulated over it, and is closed again by a counter-weight *j* or spring, or it may be opened and closed from the footplate or other convenient place by a suitable arrangement of rods and levers. (*Accepted 7th May*, 1908.)

Couplings (Automatic). *12,646. 31st May, 1907. F. H. Addis, 21, Wellington Road, Bridlington, Yorks.*

This invention relates chiefly to couplers in which both the pulling and buffing strains are taken up, and comprises a spring-controlled wedge mechanism for locking the coupler heads tightly together on mere impact, and at the same time taking up all slack or wear. On the coupling plate is pivoted at 3 the tumbler 4, which is under the pressure of the spiral spring 5. A hole or slot 6 is provided in the coupling plate, into which a pin can be inserted when desired for the purpose of a temporary coupling, with a low trolley for instance, or a vehicle not provided with an engaging head. The locking wedge 7 is operated by means of the bar 8 and outside lever 15, the spring 10 assuring the action of the wedge to fall and release the tumbler. The spring 5 is under compression, consequently the parts impelled by it cannot rest half way, but will spring into either the "fully open" or the "fully closed" position respectively. The wedge 7 has a shoulder 7^2 over which a projecting portion of the tumbler engages. Further details of the device are illustrated in Figures 4 and 5. The coupling plate 1 is here shewn connected to the car frame by means of the drawbar 26 having on each side of it a spiral spring 11, 12 respectively. These springs are placed between the base of the coupling plate and the outside of the car frame. The drawbar 26 then passes through the car frame and is provided at the

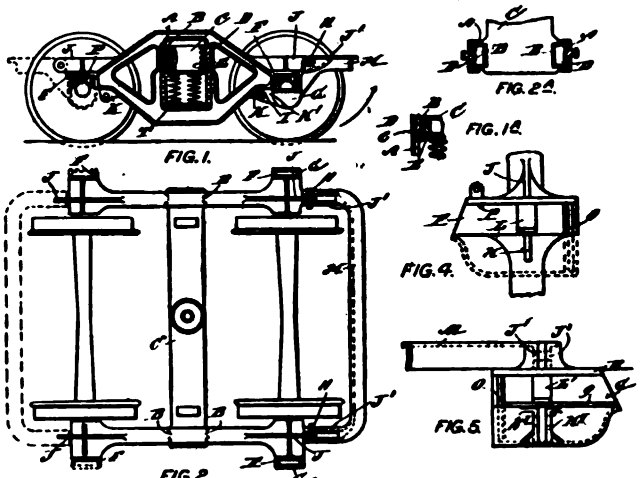


inside of the frame with a powerful spiral spring in the usual manner. By means of these double springs any twisting of the coupling is avoided. The locking lever for the actuation of the coupling wedge is also shewn. The long rod 9 is operatively connected to the arm 15 as shewn in Fig. 3. It is provided with a handle 13 at each side of the car. This rod 9 is supported by brackets 14 fixed to the car frame. Where it passes through these brackets the rod is formed rectangular or flat for a portion of its length, the bracket sleeve or holder being of like shape to admit

it. When therefore the rod is either pushed or pulled until the angled or flattened part is beyond the sleeve or holder, and the rod is then given a turn, it cannot move back to its original position until it is again rotated into that position in which the part fits the sleeve. By thus holding the rod 9 and arm 15 fast, the operator is enabled to prevent the engagement of the wedge whenever it is desired to render the automatic coupling inoperative, as for instance during shunting operations. (*Accepted 14th May, 1908.*)

Trucks. *5,143. 6th March, 1908. Date claimed under Patents and Designs Act, 1907—6th March, 1907. J. M. Rohlfing, 3840, Cleveland Avenue, St. Louis, U.S.A.*

The object of this invention is to enable the main parts, such as the bolster and axles, with the wheels, to be quickly and easily taken out and replaced without taking down the whole truck. For this purpose the journal boxes are divided and adapted to swing open to let out the wheels and axle. One portion F of each box comprising the top and part of the side, with the brass stop L, is cast integral with the side frame, and the other portion G, comprising the brass stop L¹ with side and bottom of the box, is cast separately. The parts are formed with lugs J J¹, and K

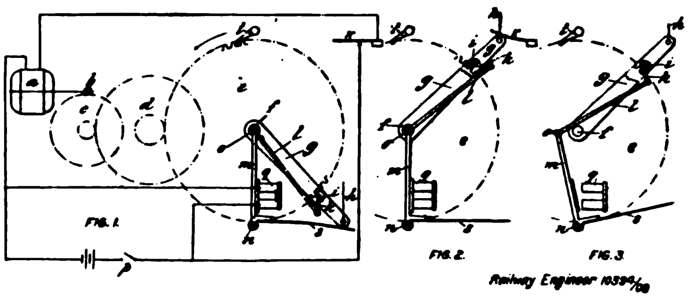


Railway Engineer 5143/08.

K¹, through which piot pins H, I, are passed for securing them together. The pins are provided with cottars for ready removal. The stops L, L¹, on the inner side of the box for the journal brass to abut against are preferably located one on the upper portion F of the box, and the other, L¹, on the lower portion G. When it is desired to open the box one pin I is withdrawn and the other pin H serves as a hinge on which to rotate the lower portion in the direction of the arrow, Fig. 1, acting to open the box at the lines of division and thus free the journal therein with its brass and wedge. It is only necessary to support the end of the truck in order to run out the axle and wheels. The bolster C is held in the side frames by removable key-blocks D. (*Accepted 30th April, 1908.*)

Signal Mechanism. *10,394. 13th May, 1908. Siemens Bros. and Co., Ltd., 12, Queen Anne's Gate, Westminster, and L. de M. G. Ferreira, 102, Elmbourne Road, Upper Tooting.*

This invention provides an electro-magnetic device for disengaging the signal arm from the gear in signals operated by an electric motor. The motor *a* drives through a worm *b* the train of wheels *c d e*, the last of which is free to turn on shaft *f*. To this shaft is keyed a lever arm *g* suitably connected, such as by rod *h*, with the signal arm. Pivoted to arm *g* is a pawl *i*, adapted to engage

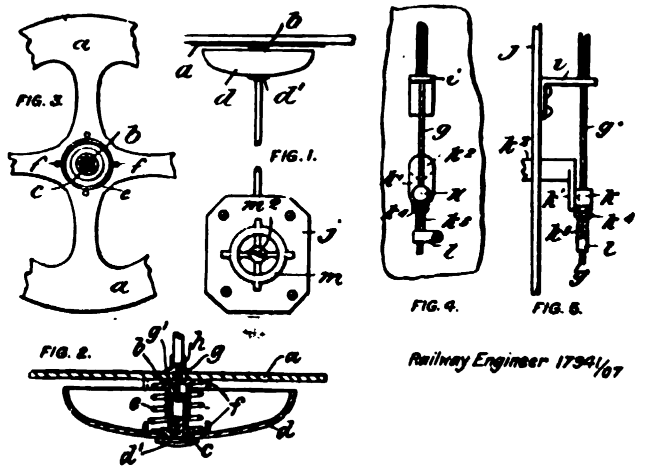


Railway Engineer 10394/08

in the teeth of wheel *e* so as to lock the arm *g* to the wheel. The pawl carries a short crank *k* connected by a link *l* with the end of a lever *m*, having as its fulcrum a stationary pin *n*. The length of this lever is such that when the lever is in position against a stationary magnet *q*, the pin *o* which connects the end of the lever with link *l* is co-axial with the shaft *f*, and the length of the link is such that so long as this co-axial relationship exists, pawl *i* is kept engaged with a tooth of the wheel *e*. This relative position of the parts is shown in Fig. 1, which is assumed to be the position when the signal has returned to danger. When switch *p* is closed to start the motor, magnet *q* is energised and lever *m* is locked in the position in which *o* and *f* are co-axial. The motor drives the wheel *e* in the direction of the arrow, and arm *g* is lifted to lower the signal until the arm lifts switch *r*, as indicated in Fig. 2, and breaks the motor circuit. The holding off circuit, however, remains completed so that the lever *m* is kept in position against the magnet *q* until the switch *p* is opened, whereupon the pressure of the weight on the signal arm, acting through the pawl and link, causes the lever *m* to fall away as indicated in Fig. 3; in this position pawl *i* is free of the teeth of wheel *e*, and the weight on the signal arm presses the arm *g* back into the position shown in Fig 1, in which it bears against the spring *s* carried by an arm on the lever *m*, so that the latter is brought back against the magnet *q*, and pawl *i* is turned into engagement with the wheel *e*. (*Accepted 25th June, 1908.*)

Carriage Ventilator. *17,941. 7th August, 1907. W. S. Laycock, Victoria Works, Millhouses, Sheffield.*

This ventilator comprises a perforated base plate *a* and a dome-shaped body *d* telescopically connected with the plate *a* by the hollow stems *b c*, but normally forced away from the plate by a spring *e*. Passing through the ends of stems *c* and *b* is a wire or cord *g*, the end of which, in order to prevent its withdrawal, is knotted as indicated at *g*¹. The cord is provided with an exterior casing, one end of which enters and abuts against the end of the hollow projection *h* secured to the back of the plate *a*, whilst the opposite end of the casing abuts against the upper surface of the bracket *i* secured to the back of a plate *j*, which is attached by screws or other means to the interior of the compartment in a



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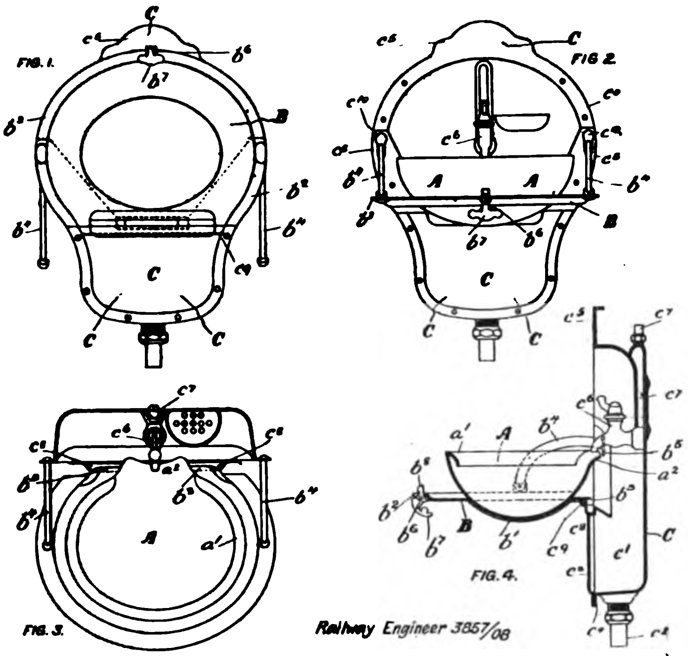
position such that it is conveniently accessible. The cord passes through the bracket at the back of plate *j*, and at its end it is secured to the projection *k* at the end of the arm *k*¹ secured to spindle *k*², which spindle passes through plate *j*. In order that the length of cord may be adjusted it is not connected directly to the projection *k*, but passes through a tube *k*³, for which a suitable perforation is formed in the projection *k*. The tube is provided upon its exterior with a screw thread and with nuts *k*⁴, the end of the cord being provided with a clamp *l*. By this means the length of the cord is readily adjusted, so that upon the rotation of the spindle the cord is pulled and the movable member of the ventilator is caused to approach the base plate, so that the entry of the air through said plate is prevented. (*Accepted 4th June, 1908.*)

Lavatory Basins. *3,857. 20th February, 1908. H. J. Beresford, of James Beresford and Sons, Cato Street Works, Birmingham.*

This invention relates to a folding basin for railway and like coaches, and provides an easily operated basin with means for preventing leakage when the basin is folded. The bowl A is mounted on a dished tray B hinged to a back piece or frame C of box form, all the parts being designed for easy stamping. In order to shield the hinge *c*⁸ during the movement of the bowl from

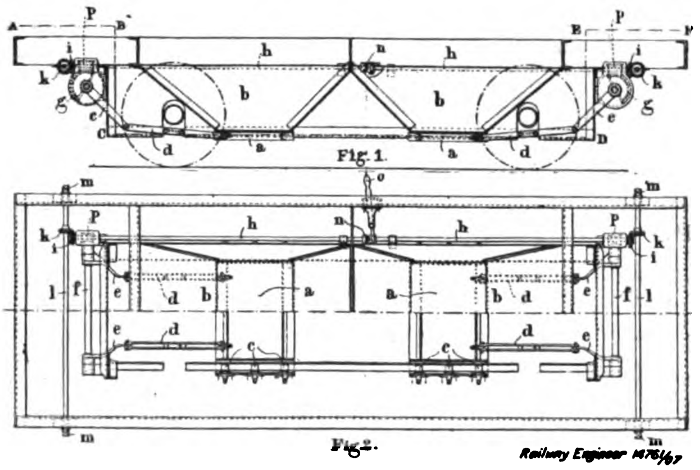
the open to the closed position an extension b^3 is formed on the tray B, which projects over the hinge and in the closed position of the bowl enters a pocket formed for its reception in the top of the



front plate c^8 of the frame C. A spring catch b^6 is provided for securing the tray in its vertical position, and adapted to be released by pulling forward the handle b^7. (*Accepted 4th June*, 1908.)

Wagon Doors. *14,761. 24th June, 1907. G. H. Sheffield, 15, New Bridge Street, Newcastle-on-Tyne, and J. D. Swinberrow, Hexham, Northumberland.*

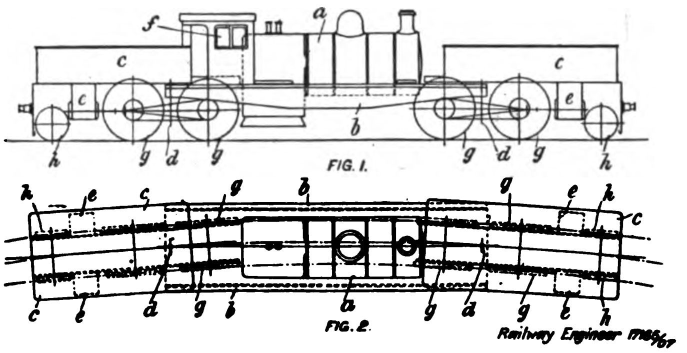
This invention consists in operating the sliding doors of a hopper wagon by means of cranks and connecting rods, through a worm gear or other self-locking mechanism, also in effecting simultaneous movement of two doors in opposite directions by so disposing the parts of the gearing as to secure a self-contained balance of the reactions. The gearing between the two doors is adapted to be disconnected so that the doors may be independently operated if required. Each door *a*, for each hopper *b*, of the wagon is suitably mounted to run horizontally upon guides, preferably on



rollers *c*, and is connected by a pair of connecting rods or links *d* to cranks *e*, mounted on a shaft *f*. A worm wheel *g* is mounted on the end of each shaft *f*, and is rotated by a worm *p* upon a shaft *h*, running longitudinally of the wagon. Each end of the shaft *h* is provided with a bevel wheel *i*, driven by another bevel wheel *k* mounted upon a cross-shaft *l*, the ends of which, *m*, are adapted to receive a key or operating lever. The pitch of the worms is made of opposite hand, to drive the shafts *f* in opposite directions, and to confine the thrust to axial stresses in the longitudinal shaft *h*. The angle of pitch is such that the worm wheel cannot drive the worm in any case. When it is desired that the two doors should be independently operated, the longitudinal shaft *h* is made in two parts, adapted to be connected by a clutch *n* of any suitable type, capable of being readily disconnected, for instance, by lever *o*, or in any other suitable manner. (*Accepted 25th June*, 1908.)

Locomotive Engines. *17,165. 26th July, 1907. H. W. Garratt, 25, Leweston Place, Portland Avenue, Stamford Hill.*

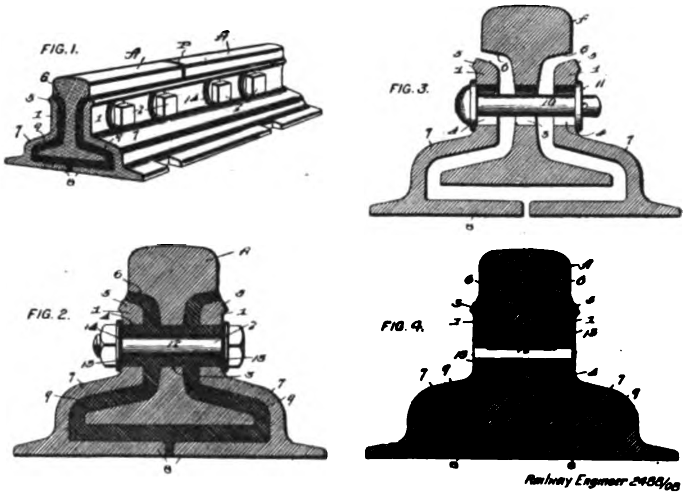
This invention relates to a double bogie engine having a large boiler with a low centre of gravity and large driving wheels on both bogies. The boiler and fittings are carried on a frame *b* of



the shortest length practicable, connected at both its ends to self-driven bogie tanks *c* by swivel heads *d*. Steam cylinder *e*, with the necessary driving gear, are carried on the bogies. (*Accepted 11th June*, 1908.)

Insulated Rail Joints. *2,488. 4th February, 1908. B. Wolhaupter, 29, West 34th Street, New York City, U.S.A.*

According to this invention the rails and fish plates 1 are arranged to form a moulding space between them, in which insulating material 9 is moulded in a plastic state so as to form an integrated body of insulation. In order to make proper provision for the insulation of the bolts 2 in the bolt-holes 3 and 4, temporary bolt-hole cores 10 are arranged through the aligned bolt-holes 3 and 4 and supported on the side plates 1, through the medium of any suitable holding means 11. The temporary cores are held in cen-

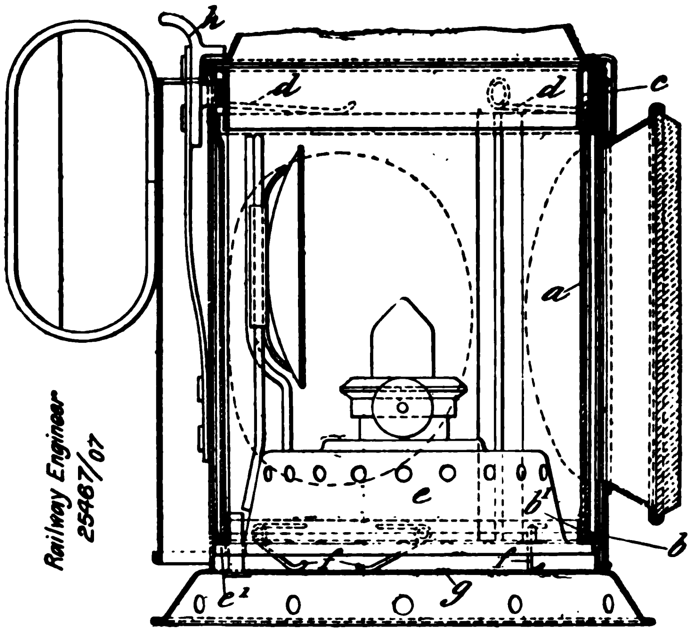


tred positions so that when, in the next step of the process, the insulating material in a plastic state is run inside the joint, such material will find and fill all spaces and will also flow about the cores 10, into the bolt-holes 3 and 4, with the result of forming an integral insulating bolt sleeve 12, within the bolt-hole 3, in the rail web, and integral insulating bolt thimbles 13, within the bolt-holes 4 of the side plates. After the insulating material has set sufficiently, the temporary cores 10 are replaced by the joint bolts 2, which may be supplied at their ends with insulating washers 14. (*Accepted 4th June*, 1908.)

Signal Lamps. *25,467. 16th November, 1907. W. H. J. Welch, 33, Lichfield Road, Bow.*

This invention provides for the ready removal and insertion of the lantern glasses or windows of hand signal lamps, and also provides means for preventing rattling or displacement of the lamp reservoir. The revolving cylinder which carries the variously coloured signalling glasses *a* is made with a shallow channel *b* at its lower end and a channel *c* at its upper end deep enough to

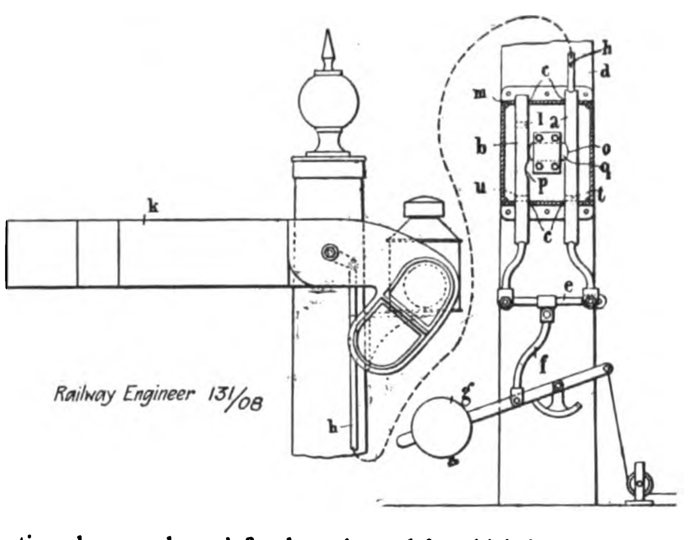
enable the lower edges of the glasses when pushed upwards into the channel c against the springs d seated in the groove to pass over the ledge b^1 of the channel b within which they are firmly



but removably secured by the reaction of the springs d. The base of the oil reservoir e has springs f on its under side which are compressed against the base g of the lamp casing when the revolving casing is inserted and held in position in the outer casing by the spring latch h, the lower channel b of the revolvable casing engaging the projecting rim e^1 of the base of the oil reservoir. (*Accepted 25th June*, 1908.)

Semaphore Signals. *131. 2nd January, 1908. H. R. Mott, "Hillcrest," Elmbourne Road, Upper Tooting, Surrey.*

This invention relates to signals or semaphores, and has for its object to prevent the drooping of the arms of such signals caused by the collection of snow or other like cause. Two locking bars a b are provided, sliding vertically in guides c c, secured in any convenient position on the signal post d. These bars are connected at their lower ends by means of a lever e, to which the rod f, connecting to the counter-weight g is pivoted. One of the bars a is



continued upwards and fixed to the rod h, which is connected to the signal arm k, and operates that arm in the usual manner. The other bar b is adapted to slide upwards through a short distance until its stop l comes against the guide bracket m. The two bars a b are provided with notches o p, adapted to engage with a cross piece q, sliding horizontally. When the signal k is at the "danger" position and the counterweight g is in its lowest and normal position, the cross piece q engages with a notch in the bar a, and locks that bar and, therefore, the signal arm in the "danger" position. The other end of the cross piece q then rests against the flat part of the second bar b; on an upward movement of the counterweight g taking place, the second bar b moves upward until its notch p comes opposite the end of the cross piece q, and when in this position the bar rests against its stop and cannot move further in the vertical direction. The further movement upwards of the counterweight operates the signal arm and lowers it. It will be seen that when the signal arm is in the "danger" position the cross piece q is prevented from moving from the notch in the bar a connected to the signal by reason that its opposite end is against the flat surface of the second bar b, and the two ends of the cross piece and the notches in the bars are so formed that the movement of the cross piece is effected by the movement of the bars in the vertical direction. The rod f connecting to the counterweight is preferably fixed to the middle of the link e, joining the lower ends of the two bars a b, and on the first movement of the counterweight this link turns about the lower end of the bar a, while on the further movement of the counterweight the link turns about the lower end of the bar b. On the return of the signal to the "danger" position by the lowering of the counterweight, the bar a first falls to stop t, and then bar b to stop u, forcing cross piece q again into the notch o in the bar connected to the signal, and locks the latter at the "danger" position. (*Accepted 18th June*, 1908.)

COMPLETE SPECIFICATIONS ACCEPTED.

A.D. 1907.

10455. Automatic apparatus for stopping trains. McCollum.
12472. Means for signalling and stopping railway vehicles. Willis.
12485. Apparatus for operating switch points and signals. Johnson.
13032. Systems for electric railways. Eastwood.
13706. Railway embankment cleaners. Persson.
14183. Electrical signalling system for railways and apparatus therefor. Enderlein, Landwehr and Schulz.
14390. Spark arresters for locomotives. Hubner.
14518. Signalling or alarm apparatus for railways. Boult.
14519. Signalling apparatus for railways. Boult.
14572. Means for electrically detecting the position of the switch tongues and locking bolts of railway points. Haywood, and McKenzie and Holland, Ltd.
14761. Mechanism for operating the sliding doors of self-discharging railway and other wagons. Sheffield and Twinberrow.
15967. Air brakes. Van Dyke.
16659. Railway fog-signalling apparatus. Treacher.
17165. Locomotive engines. Garratt.
17941. Ventilator for railway carriages. Laycock.
18452. Automatic fog signal alarms for railways controlled by distant signal levers in the signal cabin. Wootton and Wootton.
19596. Dust excluder for railway and tramway axle boxes and the like. Demolder.
20487. Windows for railway carriage doors, tramcars, vehicles, and other purposes. Le Maitre.
20510. Brakes for railway and other vehicles. Simpson.
21241. Device for automatically locking and unlocking railway carriage doors. Eckersley.
24056. Railway and tramway guide and bearing rails, bars, or plates, and rolling stock fittings for same. Thomas.
24362. Axle trucks of railway and tramway vehicles. Barber.
25351. Railway signalling. Jones.
25467. Railway hand-signalling lamps. Welch.
25616. Indicators for conveying signals to the drivers of a locomotive. Barnett.
26621. Signal and point mechanism. Cumont and Compagnie de Signaux Electriques pour Chemins de Fer.
27292. Means for fastening in position railway spikes. Lakhovsky.
28256. Automatic car couplings. Buchmeier and Zimmermann.
28273. Cord grip for railway wagon, tarpaulins, and the like. Spence and Spence.
28420. Railway trucks or wagons. Lambert.

A.D. 1908.

131. Railway signals and the like. Mott.
1914. Train controlling mechanism for automatically applying the brakes. Thompson.
2488. Insulated joints for railway rails. Wolhaupter.
2614. Ash-pans for locomotives and the like. Wilson and Goldie.
3471. Apparatus for signalling on railways and stopping trains independently of the driver. Jacquemin and Engels.
3857. Lavatory basins for railway and like coaches. Beresford.
4831. Electrical block apparatus or the like for railways. Siemens Bros. and Co.
5492. Railroad rail-brace. Ropp.
5594. Detonating railway fog signals. Ludlow.
6032. Device for stopping railway trains. Forster.
7374. Insulated railway rail joists. Wolhaupter.
7513. Railway and tramway wheels. Kitson.
7979. Means for opening and closing carriage windows. Schiel and Schwank.
7913. Railway fog-signalling apparatus. Parker.
8149. Apparatus for signalling on railways and for stopping trains independently of the drivers. Enk.
10394. Mechanism for electrically operating railway and like signals. Siemens Bros and Co., and Ferreira.

Official Reports on Recent Accidents.

Between **Waterford and Kilmeadon, G.S. & W.R.** *On 13th December. Lt.-Col. P. G. von Donop, R.E., reports that:—*

The 7 p.m. passenger train (6 coupled engine, tender and 9 vehicles fitted with the vacuum brake) from Waterford South to Mallow, ran into two wagons at a speed of between 40 and 50 miles an hour. One passenger was slightly injured. One of the wagons was destroyed.

There are two stations at Waterford on the north and south sides of the Suir. The collision occurred about 2¼ miles from Waterford South, on the single line from Waterword South to Dungarvan, and at a point situated 1¼ miles from Waterford South is Grace Dieu Junction. A single line has recently been constructed to connect Waterford North with the Dungarvan line and which crosses the Suir by a bridge, and connects with the Dungarvan line at Grace Dieu Junction.

The gradient from Waterford South to Grace Dieu Jun. mostly rises chiefly at 1 in 70 or 1 in 81. After passing Grace Dieu Jun. the gradient falls for about 1¼ miles chiefly at 1 in 81. It is then level for about ½ a mile, and it was on this level portion that this collision occurred.

The driver was in possession of the staff. There was no light at the rear end of the wagon, and as it was quite dark at the time driver Geaney could not have been expected to have sighted the obstruction sooner than he did. The brakes acted well. Every evening a shipping train is run from Waterford South to Waterford North to connect with the train to Rosslare.

It appears to have been customary in working this train from Waterford South to Waterford North for the vehicles to be pushed by the engine from Waterford South to Grace Dieu Jun., and for them to be then drawn by the engine from that Junction to Waterford North. This practice is distinctly at variance with Rule No. 179, which states that engines are never to push trains upon running lines except under certain conditions, none of which obtained on this occasion.

The marshalling of the train was then carried out by head porter O'Flaherty, and it was also witnessed by shunter Kirby, who had come with the engine from Waterford North, and who was to act as the guard of the shipping train.

All the vehicles were fitted with the automatic vacuum brake, but, owing to the fact that there was no vacuum brake pipe at the front end of the engine, that brake could not be made any use of. Kirby states that he himself coupled up the engine to the wagon standing next it, and that he saw O'Flaherty couple up the other wagons. O'Flaherty, on the other hand, states that he himself did not couple up any of the wagons together, but that he saw Kirby do so. Both men therefore deny having coupled up the two pairs of wagons together, and, though Kirby states that before starting he saw that all the wagons of his train were coupled up, there is not the slightest doubt but that the coupling between the second and third wagons was never made at all.

No van was attached to the train. In connection with this point shunter Kirby states that he has been travelling regularly on this train for twelve months and that he has never seen a brake van on it; driver Biganne states that he has been working the train for upwards of ten months, and that it has sometimes had a brake van on it and sometimes not. This practice is also distinctly at variance with Rule No. 207, which states that without special authority of the superintendent of the line no goods train must be run on any running line without a brake van in the rear, and that, when so authorised to run, a man provided with the necessary signals must ride on the last wagon.

A red light was fixed by shunter Kirby on the leading end of the leading vehicle of the train to act as a head light, and a red lamp was also attached at the rear end of the tender to act as a tail lamp. It is customary to use a red light as the head light of this train whilst it is being propelled to Grace Dieu. The Co. does not appear to have any definite regulation as to what lights should be carried as a head light on a train which is being pushed; there can, however, be no doubt that the leading vehicle should carry the same head lights as would be carried by the engine of the train if it was drawing it instead of propelling it. To carry a tail light as the head light of a train, as was done on this occasion, is manifestly wrong.

The train accordingly started from Waterford South, Kirby riding, however, on the footplate of the engine. The train slowed down when passing the Waterford South signal-box in order to get the staff of the section, but it did not come to an actual stand there, and it then proceeded to Grace Dieu Jun.

As stated above the gradient from Waterford South to Grace Dieu Jun. is practically a rising one the whole way, but immediately beyond that junction it changes to a falling one. The Shipping train ran through the junction past the signalling box and driver Biganne brought his engine to a stand just beyond the points of the connection leading to Waterford North. There is no doubt that when the engine came to a stand at this spot the two leading vehicles of the train, owing to their not being coupled up to the remaining vehicles, did not come to a stand at all, but ran on with sufficient impetus to carry them over the summit; the gradient then being a falling one, these two wagons continued to run on until they finally came to rest at the spot where the collision took place.

At Grace Dieu the signalman (Gaule) told the driver that his head light was out, and the fireman re-lighted it and changed it from a red to a white light so as to act as a head light, and, the staff having been changed, the train proceeded to Waterford North. Kirby never left the footplate of the engine, and it is evident that he did not take any steps to ascertain whether his train was complete. A red tail lamp had, as stated above, been used as the head light of the train whilst it was being propelled; that lamp did not therefore require to be changed when it became the tail light of the train, and Kirby had not therefore to go to the rear of the train on that account. Had a proper head light been fixed on the train Kirby should have changed it to a tail light at Grace Dieu Jun., and when doing so he would have discovered the fact that two of his vehicles were missing.

Signalman Gaule states that after giving the driver the staff he returned to the signal-box, and on arriving there he noticed that there was no tail light showing on the rear vehicle of the train, but he states that it had then proceeded too far for him to stop it. The steps which a signalman should take when he is unable to satisfy himself that a train which passes his box is complete are very clearly laid down in the regulations for block working, but Gaule omitted to take any action in accordance with these instructions. He neglected to send the "Train passed without tail lamp" signal to Waterford West signal-box and, without waiting to ascertain whether the train was complete or not, he sent the "Train out of section" signal for it to Waterford South, and at 6.50 p.m. he accepted the 7 p.m. passenger train from that box. The passenger train arrived at the junction at 7.4 p.m., and after exchanging staffs proceeded towards Kilmeadan, coming into collision, as described above, with the two runaway vehicles of the shipping train.

As it passed the Waterford West signal-box, signalman O'Rourke saw that there was no light on the tail end of the train, and he accordingly at once rang up Grace Dieu Jun. and asked Gaule how many wagons there were on it when it started from the junction. Gaule replied that there had been two wagons on the train when it left the junction, and that it was all right about the tail lamp, as there had been none on the train when it passed his box. This conversation, which took place about 7 p.m., was clearly the first occasion on which Gaule communicated to anyone the fact of there not having been a tail lamp on the train.

When the shipping train arrived at the check platform shunter Kirby discovered that two of the wagons of his train were missing. He at once went to the signal-box and instructed signalman O'Rourke to warn signalman Gaule of what had happened, so as to stop the 7 p.m. passenger train from Waterford South. The message, however, arrived just after that train had left the junction, so it was then too late to take any steps to prevent the accident.

It appears, however, from the evidence, that the irregularities in the working of the shipping train were not exceptional ones. It is these continued irregularities which should be regarded as the primary cause of this accident. The officials responsible for the working of the local traffic between Waterford North and Waterford South should certainly have known of these irregularities, and should have put a stop to them. It is on them, therefore, that the responsibility for this accident must greatly rest.

*

At **Maynooth Station, M.G.W.R. of I.** *On 13th March. Major J. W. Pringle reports that:—*

The midnight up mail train (4-4-0 engine, tender and 15 vehicles) from Galway to Dublin ran into an empty four-wheeled covered cattle wagon at a speed of about 30 miles an hour. The left-hand end of the buffer beam of the engine first came into contact with the wagon, and probably threw its leading end against a bank. The front six vehicles behind the engine scraped past the obstacle without serious damage, and escaped derailment. But the wagon was driven forward by successive blows received from the passing vehicles, and got jammed between them and the bank, which was gashed at three or four different places. The last 9 vehicles therefore suffered more severely than the first six. The body was swept clean off the 9th vehicle; the 10th was overturned, and the other vans and carriages were either wholly or partially derailed, and their framing much damaged.

The guard, who was riding in the 9th vehicle, was killed; a P.O. official and a spare guard, travelling home "off duty" in the last brake van, complained of injury.

The train was fitted throughout with the vacuum brake working blocks on the four coupled, 6 tender, and 60 out of the 78 truck and coach wheels.

Maynooth Station is about 14½ miles from Broadstone (Dublin) terminus.

There are two cross-over roads between the main lines, one at each end of the station yard. From the up main line access is provided, by two sets of trailing points, to two separate sidings. Of these, one is known as the up goods siding, and has a length of 55 yards, terminating at the eastern end of the up platform. The other, termed the up cattle bank siding, extends for a distance of 300 yards westward of the platform and parallel with the up main line. The cattle wagon with which the mail train came into collision was standing outside the safety points on this cattle bank siding.

This accident took place on a dark night, an hour or two after the moon had set, the mail train was not booked to stop at Maynooth, and that there were no lights burning about the station, in the signal-box and on the signal posts.

The wagon stood foul on the left of the line and was not lighted; the train approached it on a left-hand curve and all the signals showed a "clear" road. Wilson, the driver, standing on the right-hand side of the foot plate, saw nothing of the obstruction before the collision took place.

The 1 a.m. down goods from North Wall, Dublin, had 5 goods wagons to be dropped at Maynooth, and in accordance with custom had to be placed in the up goods siding at the east end of the up platform. The

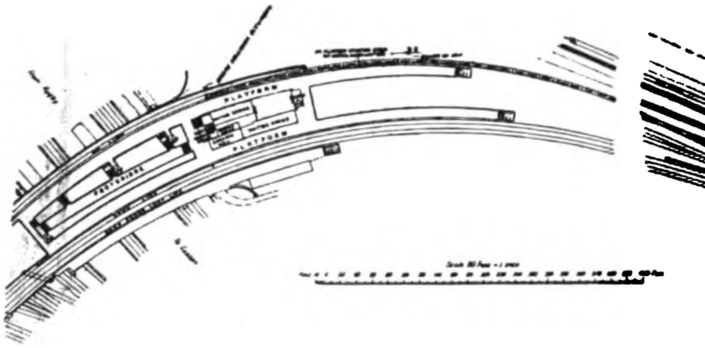
wagons were therefore uncoupled, and drawn ahead clear of the eastern cross-over road. The engine was unhooked and ran round the wagons by the two cross-overs. Lennon (guard) then found that there was only room in the up goods siding for 4 of the wagons. Madden (signal man), on being informed of this, told Lennon to put the fifth wagon into the up cattle bank siding at the west end of the platform. He added that before doing this it would be necessary to lift an empty cattle wagon out of this siding, and keep it in front of the loaded goods wagon, as the cattle wagon was required in the morning.

Accordingly the engine propelled the loaded goods wagon into the up cattle bank siding, where Lennon coupled it to the empty cattle wagon. The two wagons were drawn out on to the main line, and the cattle wagon shunted clear of the points leading to the cattle bank siding. Lennon then uncoupled the goods wagon, which was loose shunted into the cattle bank siding. The engine ran out of the siding, and then forward on the up main line to where the cattle wagon was standing. Lennon coupled it to the engine and it was drawn forward clear of the siding points. The wagon came to rest eight or ten yards east of the points, and Lennon again uncoupled it. On each occasion that the points required to be set or reversed, Madden worked his lever in the signal-box in obedience to a whistle from the engine. The engine then shunted the cattle wagon into the siding, and came to a stand 10 yards inside the points. Lennon during this operation was standing opposite the points, and followed the wagon after the engine stopped, until he saw it pass over the catch points into the siding, and then came back to the engine. Lennon may possibly be mistaken in thinking he followed the wagon as far as the safety points. It was of course quite dark, and he had only his hand lamp to light him. On returning to the engine Lennon mounted the bottom step, and the engine returned to its train, passing the signal-box on its way. As the engine passed Lennon shouted to the signalman to shut up the cattle bank points. Madden replaced his lever, and must have done so immediately, otherwise the interlocking would have prevented him from setting the points of the east cross-over road for the engine to return to its train.

The goods train then drew forward to the down platform, and the driver watered his engine. The water column is situated at the west end of the down platform, about 65 yards from the spot where the cattle wagon stood when the collision occurred. Whilst the tender was filling, signalman Madden and guard Lennon were engaged in loading five bags of meal from the down platform on to the goods train. The goods train finally left Maynooth at 4.17 a.m., and Madden returned to his post at 4.19, crossing the permanent way opposite his signal-box. On his return the bell signal for the approach of the mail train was received, and the collision took place at 4.25 a.m.

Conway and Lennon, when their train started, must have passed within 15 or 18 feet of the empty cattle wagon, as it stood foul of the up line, but it is evident they did not look in its direction, or they would have noticed its position.

There appear to be only two alternative explanations for the position of the empty cattle wagon when the accident occurred :—(*a*) The velocity attained by the wagon, when the engine stopped pushing it, may not have been sufficient to carry it round the curve inside the safety points. Or, (*b*) it attained a considerable speed, and striking the goods wagon previously shunted into the siding may have rebounded so that it stood foul of the main line.



Whichever alternative be correct, the Co.'s Rules and Regulations show clearly that the responsibility for the position of the wagon outside the safety points of the siding rests with guard Lennon. It was his duty, Rule 225 (*a*), to see the points properly closed. After following the vehicle over the safety points, and if necessary putting down the brake in accordance with Rule 19 (*a*), he should have come back to the safety points and seen them properly closed before leaving the place. It is probable that owing to the train being late, and to the further delay caused by having to shunt the empty cattle wagon, he hurried over his work. He had been on duty about 3½ hours, and had been off duty for 21 hours previously. He bears a good character, and there is no record against him in the discipline book.

As regards lighting, Rule 5 made by the Board of Trade in connection with the Railway Employment (Prevention of Accidents) Act, 1900, reads as follows :—

"All stations and sidings where shunting operations are frequently carried on after dark must be sufficiently lighted."

With the exception of special cattle trains during fairs, only one goods train works at Maynooth during night. When special trains, involving additional shunting, are worked, extra assistance is provided. Occasional supervision of the manner in which shunting operations are carried out at this station during the night time is desirable.

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***At* Willesden (High Level) Station, L. & N.W.R.** *On the 11th November. Lt.-Col. H. A. Yorke reports that* :—

The North London train from Richmond was run into by a L. and N.W. light engine, which was travelling in the opposite direction along the same line of rails. The drivers, firemen, and guards and 13 passengers were injured.

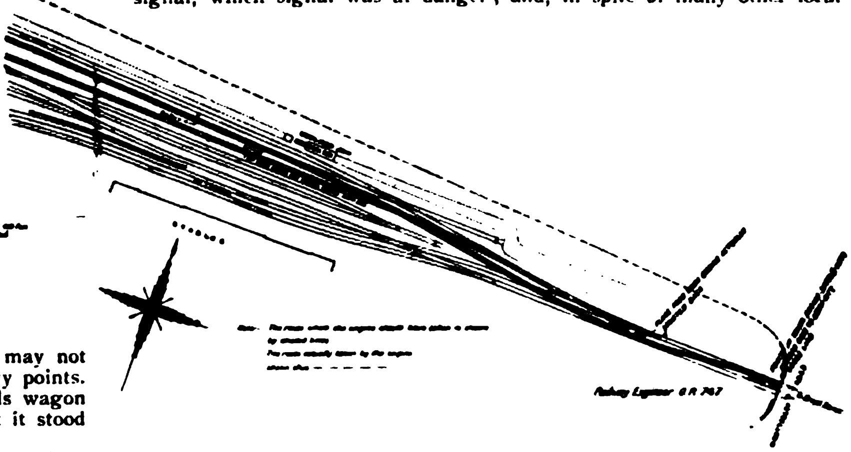
The two engines, which were a good deal damaged, became buffer-locked, and the couplings between the train engine and its train were broken. The engines were separated from the train by two coach lengths; the front van was smashed; the carriage next the van badly damaged; and all the others slightly damaged.

The collision occurred near the middle of the up high level platform. A plan of the place is attached. A dense fog prevailed at the time of the accident, and the fogmen were at their posts.

The light engine arrived at Willesden at 5.23 p.m., and was stopped at the High Level Junction home signal, which is at the west end of the station, and also at the platform starting signal at the east end, the fog rendering it necessary to stop in order to see whether the signals were off. Howes then took his engine forward to Kensal Green Junction for the purpose of returning to the locomotive shed. Usually, engines coming from Kew reach the locomotive shed through the sidings at the west end of the station, but sometimes, as on the present occasion, it is more convenient for them to pass through Willesden Station and get to the shed *viâ* Kensal Green Junction.

The light engine passed Kensal Green Junction signal-box at 5.27 p.m., and driver Howes called out "Loco." to the signalman as he passed the box, meaning thereby that he wanted the points set for him to proceed to the locomotive shed.

When Howes first stopped his engine at the eastern end of the cross-over road he thought he had gone too far, and so he set back towards the junction until, as he guessed, he was near the eastern extremity of the cross-over road. But there is no doubt that owing to the fog he again misjudged his position, and came back too far, and instead of stopping near the points of the eastern end of the cross-over road, he stopped near the western, *i.e.*, the Willesden end of it. Under these circumstances, the disc signal which he saw was that which related to a movement in the opposite direction to that which he had to make, and it of course was not pulled off. When, therefore, he set back in answer to the signalman's shout, he was altogether clear of the cross-over road, and did not pass through it on to the down line and thence on to the down City goods line, but simply returned along the up line. He must have been very unobservant, for not only did he not notice the absence of the inevitable lurch of the engine which would have occurred had he passed through the cross-over road and the junction, but he also failed to hear the explosion of the detonator which the fogman had placed on the up line alongside of the junction home signal, which signal was at danger; and, in spite of many other local



indications, which, had he been on the alert should have attracted his attention, he did not become aware of the fact that he was on the wrong line until he reached the station and saw the North London train close in front of him. He had been on duty about 2 hours.

Signalman Alcott showed a want of discretion in shouting to the driver to come back, without having first ascertained what was delaying him. Had he sent fogman Sharman to see what was wrong, it is probable that the position of the engine would have been discovered before it started on its return journey. Orders conveyed to drivers by shouting are always liable to be misunderstood, and this is especially the case in time of fog. His shouting to the driver was due to his anxiety to clear the road for the N.L. train.

It has been decided to lay in a cross-over road between the up main line and the down City goods line immediately opposite the Kensal Green Junction signal-box. This will enable the movement of engines from the up main to the down City goods line, on their way to the

locomotive shed, to be made under the immediate view of the signalman. It will also have the advantage of saving delay, and should prevent any repetition of a mistake such as that which occurred on this occasion.

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At **Bolton, L. & Y.R.** *On March 16th. Lieut.-Col. E. Druitt, R.E., reports that:—*

The 6.57 a.m. train from Liverpool ran into the rear of the 7.27 a.m. train from Blackburn. Three passengers complained of injury.

Approaching Bolton Station the up line from Blackburn runs from the northward, and the up line from Liverpool direction from the westward, and Bolton West signal-box is in the angle between them.

The 7.27 a.m. ex. Blackburn arrived at Bolton at 8.10 a.m. and was turned by signalman R. Nelson as usual on to the up main platform line, the tail van of the train being about 70 yards from the end of the platform. At 8.10 a.m. Nelson was offered the 6.57 a.m. train ex. Liverpool from Bullfield East signal-box, and at once accepted it. He had offered it to the up box and it was accepted by that signal-box on the up loop line, which runs on the other side of the up platform, at 8.11 a.m., and it arrived at 8.13 a.m. Nelson, however, though sending the block signals for this train to run on the up loop line, did not set the road for the up loop line, and lowered the up main line signals, so the Liverpool train was turned on to the same platform line as that on which the train from Blackburn was standing.

Owing to the sharp curve in the line approaching the station and to an overbridge there is not a good view for any distance for a driver approaching Bolton from the north, so neither driver Johnson nor his fireman were able to see the train in front in time to quite stop their train before it collided with the tail of the train from Blackburn.

Nelson is an experienced signalman with an excellent record, and had been on duty for 2¼ hours after an interval for rest of 12 hours.

*

At **Seacombe and Egremont, W.R.** *On the 4th and 6th March. Lt.-Col. E. Druitt, R.E., reports that:—*

The Gt. Central R.'s 6.5 p.m. passenger train from Seacombe to Wrexham was partly derailed. Two passengers complained of injury. The train consisted of a 6-coupled tank engine with a trailing radial axle, fitted with the automatic vacuum brake, and 5 vehicles—four with six wheels and one with four wheels. Weight of engine 59 tons 18 cwt., and fixed wheel base 16ft. 6in.

There was also a passenger train derailed at the same spot on the 6th March, viz., the 8.55 p.m. Seacombe to Wrexham, consisting of a 4-coupled tank engine with a leading bogie and trailing pony truck fitted with the steam brake on the four coupled wheels, and of five six-wheeled coaches fitted with the vacuum brake on all wheels with the exception of the centre pairs. Weight of engine 66 tons 12 cwt. The carriages derailed were the fourth and fifth.

The three platform lines at Seacombe Station run approximately east and west, and No. 3 platform, from which the derailed trains started, is on the north side of the others. It is 498 feet in length. The starting signal is just beyond the western end of the platform. This platform is used for both the arrival and departure of trains, so there is a through connection from this line to the down main line crossing the up main line. The points facing to trains leaving No. 3 platform are just ahead of the starting signal at the west end of the platform, and are known as No. 17; they are provided with the usual facing point lock and lock bar. Just before reaching the facing points the platform line is on a curve to the left (for departing trains) of 640ft. radius, and with a super-elevation of the outer rail of 2¼ inches. The switch rails are 12ft. in length, and are connected to the fixed rails at their heels by fishplates and bolts. Beyond the facing points the radius of the outer rail of the turnout leading to the down main line is successively 909ft., 1,067ft., 960ft., 873ft., 515ft., 343ft., and 300ft., for a total distance of 90ft. The super-elevation of the outer rail at the facing points is 2¼ inches, diminishing gradually to 1¼ inches in a distance of 54ft., and dies out near the crossing of the up main line 50ft. further on.

The driver of the train, C. Craven, also states that, on examining the rails after the accident, he found the fishplate bolts connecting the right-hand switch rail to the fixed rail quite loose, and the inner edge of the butt end of the fixed rail projected inside the inner edge of the heel of the switch rail. His evidence as to this is supported by that of guard Roberts, of the Gt. C. train, and also by that of W. Martlew, locomotive foreman of the Wirral R., as regards the projection of the butt rail inside the heel of the switch rail. Mr. T. B. Hunter, the locomotive superintendent of the Wirral R., also examined the joint a few hours after the derailment, and states that the projection of the end of the butt rail inside the heel of the switch rail may have been ¼in., and that he could see the mark where the flange of a wheel had struck the rail and begun to mount just at the end of the butt rail.

He also suggests that the strong wind blowing at the time broadside on to the coaches helped the leading right-hand wheel of the four-wheeled coach to bind against the rail and gradually mount it. Some days after the accident no mark on the butt end of the rail which could positively be stated to be caused by a flange striking it could be seen, as it was a cut rail, and the end had several marks possibly made when the rail was cut. The inner edge of the head of the rail was very bright and polished, showing, as might be expected from the sharp curve of the turn out, that the wheel flanges are pressed very tight against it. The right-hand switch rail was also considerably worn on the surface and was appreciably lower at the head than the top of the butt rail adjoining. The small worn patch at the end was formed by the treads of the wheels striking the end of the rail as they jumped on to it from the lower switch rail, and had been a gradual process. The speed of the train was probably 10 miles an hour or more when the four-wheeled carriage reached the point of derailment; the engine would then have travelled some 125 yards from where it started, and was a powerful tank engine with only five light coaches behind it weighing together only 59 tons, and, according to the fireman's statement, it ran 70 yards after the driver applied the brakes when he felt the pull on the engine. On examination of the derailed coaches there was nothing found to account for the derailment. The leading pair of wheels of the four-wheeled coach, the third from the engine were the first to be derailed, caused probably by the jump the right-hand wheel would make on coming on to the butt end of the fixed rail, possibly helped by a tight coupling between the second and third coaches. The flange of the right-hand wheel would be pressing hard against the right-hand rail, and would tend to mount the rail, and the higher the speed the greater would be the combined effect of the several causes. The possibility of a tight coupling is shown by the absence of any permanent flange mark on the head of the rail, and the very slight damage done for the first 64 yards beyond the point of derailment, viz., three chairs broken and a check rail displaced opposite the V-crossing in the up line. Also the driver felt no pull on the engine until he reached the Luke Street overbridge 100 yards ahead of No. 17 points, from which it would appear that the leading end of the third coach was held up by the second.

The second derailment took place two days after the first at 8.58 p.m. on the 6th. The damaged permanent way had been replaced on the previous day, the 5th, and the crossing had been in use during the 6th.

The train consisted of five vehicles, and the fourth and fifth were derailed, the fifth also becoming detached from the fourth, severing the brake pipe connection and pulling up the train, the rear being only 25yds. beyond the point of derailment. There was about 5ft. between the fourth and fifth coaches. The driver and guard examined the rails soon afterwards and found the mark of a flange close by the end of the fixed rail at the heel of the right-hand switch rail, showing where the derailment had occurred, which was the same spot as the derailment of two days earlier.

Mr. Whittingham, the district carriage inspector G.C.R., also gave evidence as to the condition of the joints between the fixed rail and the switch. At 11 a.m. on the day of this derailment, when he came to Seacombe to enquire into the derailment of the 4th, he states he found the inside edge of the end of the fixed rail projecting no less than ⅝ inch inside the edge of the heel of the switch rail, and the fishplate bolts very loose. He says he did not call the attention of the Wirral Co.'s staff to this, as he was not a permanent way man, but only had to do with the rolling stock. The causes of this derailment may be assumed to be somewhat similar to those of the previous one.

The Wirral Company have now put a speed restriction of five miles an hour for trains entering and leaving this station, which is a desirable precaution to take.

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Near **Wembley Park, G.C.R.,** *on March 14th. Major J. W. Pringle reports that:—*

The 7.30 p.m. down train (Marylebone Station to Leicester), consisting of a 4-4-2 engine and tender and 5 bogie coaches, was derailed. The train was divided between the tender and the first coach. The engine was on the rails; the tender wheels were derailed towards the six-foot way (right-hand side); 290 yards behind the engine, the 5 coaches, with couplings intact, stopped on the left of the road. The first coach was half-way down the low embankment, resting on its left side, and supported in that position by trees and the railway fencing. The last coach was standing on its wheels on the edge of the formation. The three middle coaches occupied intermediate positions at varying angles, some of them being also partially supported by the branches of trees. Four passengers suffered from violent shaking, and one from cuts on the face.

The train was fitted with the automatic vacuum brake to all wheels blocked, and the engine and tender with a steam brake, automatically controlled by the train pipe vacuum.

About 475 yards of permanent way had to be relaid, nearly all the chairs being broken, and many sleepers destroyed: no rail or fishplate was broken.

This derailment took place on the down main line, between Brent North Junction and Harrow South Junction, in close proximity to Wembley Park Station (Met. R.). The line is straight for a length of 195yds. west of Brent North Junction signal-box, when a left-hand 50ch. curve is followed by a tangent 107yds. long, when there is a right-hand 40ch. transition curve.

From Neasden South Junction on the down line the road is practically level for 790 yards, then falls at 1 in 565 for 433yds., then rises for 1 in 620 for 366yds., then at 1 in 200 for 355yds.

The first sign of derailment was found about 357yds. west of Brent North Junction signal-box. This spot (A) is 162yds. from the commencement of the left-hand 50chn. curve, and on the up gradient of 1 in 200. Here almost in the centre, and on the inside edge, of a right-hand rail, a mark began to be visible. It ran almost in a dead straight line diagonally across the rail head, over the first joint, and finally disappeared on the outside edge of the rail, about 30 feet from its commencement. The mark was of very even width, dark in colour as if caused by a greasy flange. If rubbed with the finger most of the mark could be dissipated, and only a very slight score on the rail head remained visible. The mark was almost exactly paralleled on the left-hand rail, where,

however, it was less distinct and lighter in colour. Beyond these marks, the outside bolt heads of the second, fifth, and sixth fishplates of the right-hand rail, counting from (A), were sheared off, and the plates found loose. Most of the keys were splintered, and some of the chairs cracked through their bases for a distance of 5½ rail lengths (55yds.). Very evidently one or more wheel flanges rode over these keys. Along the left-hand rail the outsides of the inner jaws of most of the chairs were marked with cuts or scrapes, and there were cuts also on some of the bolt heads; 65yds. from (A) the permanent way was broken up, the chairs and sleepers being badly crushed or broken. Four lengths of the left-hand rail had disappeared and were eventually found under the coaches. The trailing end of the rear coach came to rest 102yds. from (A) on the left-hand edge of the formation. The leading end of the five derailed coaches was 192yds. from (A). An interval of 290 yards separated the fore end of the tender, when it came to rest, from the nearest coach. Over the whole of this length nearly every chair under both rails was broken, and the sleepers scored by wheels running in the four-foot and six-foot ways. The right-hand rail was displaced nearly the whole of this distance, but the left-hand rail was not found so much out of position. The tender stood with all its wheels derailed towards the right of the road. The permanent way in front of the tender, where the engine stood on the rails, was quite undamaged.

The permanent way consisted of steel rails, in 30ft. lengths rolled in 1897, laid in 1899, and then 86lbs. per yard. After the accident the weight was found to be 83 to 83½lbs. per yard. The chairs weighed 39½lbs. apiece, with a bearing area of 78 sq. ins. There were 11 sleepers to the rail length. Some few of the original chairs had been replaced by new pattern chairs weighing 53lbs. each, with a bearing surface of 124 sq. ins. The fishplates (clip pattern) weighed 45lbs. per pair, and were fastened with four bolts. The ballast is gravel, varying in depth under the sleepers from 6 to 10ins.

The superelevation on the 50 chain curve was about 3 inches.

The total length of the train was 326ft. 9in., of which the engine and tender occupied 61ft. 10½in. Tender wheel base 13ft. The weights were on engine bogie 16½ tons, on coupled axles 18¾ tons, on trailing axle 18 tons; tender on leading axle 13½ tons, on middle axle 14 tons, on trailing axle 14 tons 3 cwt. Weight of 5 coaches 138 tons 2 cwt.—average 27 tons 12.4 cwt.

The total length of the train was about 109 yards, so that the whole train was travelling on the curve at the moment derailment occurred.

The speed of the train passing Brent North Junction, 357 yards from (A), is estimated by the train men at 30 to 35m. an hour, but 45m. was more probably the speed. The general condition of the permanent way warranted a speed of 50 miles an hour, which should not have been the primary cause of the derailment.

Driver Gallamore, when he noticed that the coaches had broken away, released the steam brake on the engine, so as to avoid a possible collision with the coaches which he thought were following him. This accounts for the long interval between the tender and the coaches when they respectively came to rest.

The tender had five axle boxes and the right leading spring broken. The buckle of this spring, together with the top and bottom plates, were found in position after the accident, and were then removed. The top plate was broken across through the pin hole; the bottom plate was bent and cracked through three-quarters of its thickness. The fractured surfaces of the top plate were altogether discoloured, and showed no signs of freshly broken metal. The fracture was of old standing. The exposed surfaces of the crack in the bottom plate also indicated by colour and appearance that the greater portion of the fracture was not fresh, but there were bright metallic traces along the bottom of the crack, which showed that the break had very recently been extended. The buckle had evidently been burst open through the top back side, and the bright metallic appearance showed a clean fracture of sound metal. The pin of the buckle was broken at its lower extremity.

Subsequently all the remaining parts of the spring were found with the exception of one-half of the sixth plate. The spring consisted of seven plates altogether. All the broken pieces found on the ground were discovered west of (A) at various places from 90 to 250 yards beyond. The five middle plates had, like the top plate, been broken across through the pin hole. In each case the fractured surfaces showed clearly a cup-shaped flaw round the pin hole, where the colour of the metal was almost black and smooth in appearance. Under and round this flaw the metal exposed was, to a large extent, bright and silvery and had been freshly broken. The cup-shaped flaw was also discernible in the upper part of the crack across the bottom plate.

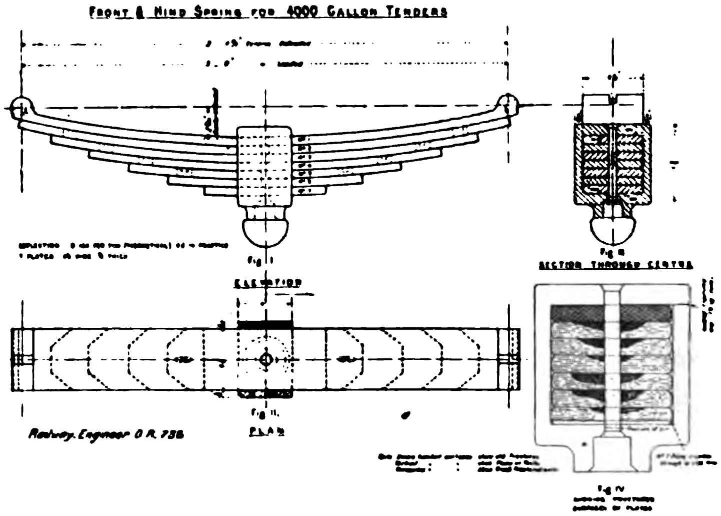
The spring buckle is made of Yorkshire iron, the plates of steel. In accordance with the Company's standard specification, a tensile strength of 22 tons is required for the iron, and from 48 to 50 tons (untempered) for the steel. The buckle was manufactured by Messrs. Steel, Peach, Tozer & Company, Sheffield, and is stamped "1906." The top plate is stamped with the name of Messrs. Thomas Turton & Son, Sheffield, and the date 1905. The remaining six plates are unmarked. The holes in the plates for the buckle pin are invariably drilled and not punched. The flaws must therefore have been due to natural causes—fatigue of material due to continual high stress. The flanges and treads of the wheels were in good running order, and were practically unmarked.

Engine No. 363 was built at the Co.'s works at Gorton, August, 1906, and arrived at Neasden, October, 1906. On the 4th October, 1907, the spring found broken after the accident was fitted to the tender at Gorton. Since this last date the engine had run 26,747 miles. The five coaches went through the shops at various dates between May and December. They were then lifted, overhauled generally, and had their wheels turned.

The circumstantial evidence indicates that the first vehicle to leave the rails was the tender. The leading tender wheels* mounted the rails at (A) and left the parallel marks on the rail heads, keys and chairs which have been described. The centre wheels, possibly by reason of the additional axle-box play, do not appear to have immediately followed suit. But six or seven rail lengths from (A) they and the trailing wheels must have crossed the rails, and completed the destruction of the chairs and destroyed the road. The coaches evidently travelled without mishap over the first 6½ lengths of rail from (A), as there are no wheel marks on any of the sleepers, and then dropped off the road, the leading bogie slewing to the left.

As to the cause of the initial derailment. Some have attributed it wholly or partly to subsidence or weakness of the permanent way. There is no evidence in support of this opinion. The rails on this section are in good order and of fair weight. The sleepers and fastenings showed no signs of weakness. In two respects the permanent way is inferior to a high-class express road. The chairs are light with a small bearing area, and the ballast is not of first-class quality or of sufficient depth below the sleepers, having regard to the clay soil on which it is laid. But there were no signs of movement other than a slight out-of-alignment of both rails (about ⅝in.) about four rail lengths before the spot (A). The only chairs broken were those damaged by derailed wheels. The fact that the heavy engine, with 18¾ tons on its coupled axles, travelled over the road without injury to its springs and caused no deformation is a final answer to this view.

There is no room for doubt that the top plate had been broken for at least some days. With this broken plate, and the existing flaws and cracks as shown on fig. 4, in all the six remaining plates, the dead breaking load of the spring has been calculated by the Company to be about eight tons. With all journals equally loaded the actual dead



load on the spring was about 5.8 tons. Taking into consideration the water load on the tender, and the movement of the train on the curve, it is not surprising that a spring in this condition should fail at any moment, without any subsidence of the permanent way to cause unusual movement or extraordinary stress.

This derailment was brought about by the failure of the right leading spring of the tender, which was in a defective condition when the engine started on its journey. The failure of the spring would momentarily relieve the journal of its load and allow the wheel to mount the rail. The broken spring plates would be held in position by the nibbing and by the buckle, until the latter was burst open after the derailment by the leverage exerted by the hangers at each end.

The only other matter for consideration is, whether it was possible for the defective spring to have been discovered by examination or test before the engine left the shed. Fitter Swift was responsible for the examination of the engine on the day in question. His evidence was not given in a very satisfactory manner. He stated that he made his usual visual examination between 3 and 4 p.m., and also tested the spring by tapping it with his hammer. He is certain that if the top plate had been broken, he would have detected it. It is equally certain that the plate was broken, and that either he could not have made a careful examination, or the usual method of examination by sight and hammer is not sufficient in all cases to detect such faults. The last alternative may be possible, if the buckle, which is shrunk on, be highly stressed, and thereby grips the plates tightly. The case therefore points to the necessity for more critical examination of springs by periodically testing them, or taking them to pieces.

***Note. — The play between the top of the axle-box and the horn plate is 1 3/16 ins. the depth of the flange is 1⅛ ins.**

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THE Railway Engineer

VOLUME XXIX., No. 346. *NOVEMBER*, 1908.

Contents.

Lord Claud Hamilton, chairman of the Great Eastern R., has joined the Executive Committee of the newly-formed Anti-Socialist Union of Great Britain and Ireland, of which the temporary offices are at 20, Victoria Street, Westminster, S.W.

Mr. F. C. Mathews, who has been solicitor to the L., Tilbury and S.R. for 26 years, has been elected a director of the company.

Mr. Guy Calthrop has been appointed general manager of the Caledonian R. in succession to the late Mr. Robert Millar. Mr. Calthrop is 38 years old. He entered the service of the L. and North Western R. at the age of 16, and in 1895 he was outdoor assistant to the superintendent of the line, and in 1901 assistant to the general manager. In 1902 he went to Glasgow as general superintendent of the Caledonian R.

Mr. E. J. Neachell has been appointed general manager and engineer of the Liverpool Overhead R. in succession to **Mr. S. B. Cottrell**, who has retired on account of ill-health, after holding the office for a period of 16 years, and **Mr. J. A. Panton**, superintendent of rolling stock, has been appointed assistant engineer.

Mr. G. W. Gower has been appointed chief assistant to the goods manager (Representative Dept.) of the Great Western R. in succession to **Mr. H. J. Humphrey**, who has retired, and **Mr. T. C. Walford**, chief assistant to the goods manager (Mineral Dept.) in succession to **Mr. H. I. Cope**, mineral manager, who has also retired.

Mr. H. C. Law, superintendent of the Bishop's Road Bridge goods offices, Paddington, Great Western R., has been appointed London district goods manager at 23, Newgate Street, E.C., in succession to **Mr. J. C. Kingett**, who has retired after 46 years' service. **Mr. W. F. Wilson**, goods agent at Poplar, succeeds Mr. Law and **Mr. F. J. Meade**, chief clerk at Bishop's Road Bridge, succeeds Mr. Wilson at Poplar.

Mr. H. E. Goodship, senior assistant accountant, Sierra Leone Government R., has been appointed assistant accountant of the Uganda R., British East Africa.

Mr. H. Marriott, assistant traffic manager, Lancashire and Yorkshire R., has been appointed passenger superintendent in succession to Mr. C. J. Nicholson, who has retired—on superannuation.

Mr. R. B. King, a guard in the service of the Great Northern R. for 37 years, has been elected Mayor of Grantham for the ensuing year.

Mr. F. H. Hart, cashier at Leicester, Great Central R., has been appointed secretary of the company's Conciliation Boards.

Mr. W. Clower, general manager's office, Midland R., has been appointed secretary of the company's Conciliation Boards.

*

WE regret to record the death of **Sir William Pollitt**, director and formerly general manager of the Great Central R. He was born in 1842, and at the age of 15 entered the audit office of the Manchester, Sheffield and Lincolnshire R. In 1869 he became chief accountant, and in 1886, after being assistant general manager for a short time, he was appointed general manager. He was knighted on the opening of the extension of the M. S. and L. R. in 1899. In 1902 he retired, and was elected a director. He was also either manager or director of all the M. S. and L. "children" now absorbed in the Gt. Central R. He died at Southport on the 14th ultimo.

*

London School of Economics.

ON the 20th ultimo Lord Claud Hamilton presented to the successful students of the railway department of the London School of Economics and Political Science the Brunel Gold Medals which have been established by Lord Winterstoke, director of the Great Western R. The successful students were W. G. Chapman, G.W.R., W. Ingleby, N.E.R., and F. M. Major, G.E.R.

*

Requirements of the Companies' Act, 1907.

SECTION 35 of the Companies' Act, 1907, which came into force on the 1st July last, will be interesting to American and other railway companies which have an office in this country. It is as follows:—

Requirements as to Companies Established Outside the United Kingdom.

35.—(1) Every company incorporated outside the United Kingdom, which at the commencement of this Act has a place of business in the United Kingdom, and every such company which after the commencement of this Act establishes such a place of business within the United Kingdom, shall within three months from the commencement of this Act or within one month from the establishment of such place of business, as the case may be, file with the registrar:

(a) a certified copy of the charter, statutes, or memorandum and articles of association, of the company, or other instrument con-

stituting or defining the constitution of the company, and, if the instrument is not written in the English language, a certified translation thereof;

(b) a list of the directors of the company;

(c) the names and addresses of some one or more persons resident in the United Kingdom authorised to accept on behalf of the company service of process and any notices required to be served on the company;

and, in the event of any alteration being made in any such instrument or in the directors or in the names or addresses of any such persons as aforesaid, the company shall file with the registrar a notice of the alteration within such time as may be prescribed.

(2) Any process or notice required to be served on the company shall be sufficiently served if addressed to any person whose name has been so filed as aforesaid and left at or sent by post to the address which has been so filed.

(3) Every company to which this section applies shall in every year file with the registrar such a statement of its affairs as would, if it were a company incorporated in the United Kingdom and having a capital divided into shares, be required under this Act to be included in the annual summary.

(4) Every company to which this section applies, and which uses the word "Limited" as part of its name, shall—

(a) in every prospectus inviting subscriptions for its shares or debentures in the United Kingdom state the country in which the company is incorporated; and

(b) conspicuously exhibit on every place where it carries on business in the United Kingdom the name of the company and the country in which the company is incorporated; and

(c) have the name of the company and of the country in which the company is incorporated mentioned in legible characters in all billheads and letter-paper, and in all notices, advertisements, and other official publications of the company.

(5) If any company to which this section applies fails to comply with any of the requirements of this section the company, and every officer or agent of the company, shall on conviction be liable to a fine not exceeding fifty pounds, or, in the case of a continuing offence, five pounds for every day during which the failure continues.

(6) For the purposes of this section the expression "certified" means certified in the prescribed manner to be a true copy or a correct translation, and a share transfer or share registration office shall be deemed to be a place of business within the meaning of this section.

(7) There shall be paid to the registrar for registering any document required by this section to be filed with him a fee of five shillings, or such smaller fee as may be prescribed.

*

Timber Supply in the United States.

"THE forests of this country, the product of centuries of growth, are fast disappearing," said Mr. James J. Hill at the Governors' Conference. "The best estimates reckon our standing merchantable timber at less than 2,000,000,000,000 feet. Our annual cut is about 40,000,000,000 feet. The lumber cut rose from 18,000,000,000 feet in 1880 to 34,000,000,000 feet in 1905; that is, it nearly doubled in 25 years. We are now using annually 500ft. board measure of timber per capita, as against an average of 60ft. for all Europe. The New England supply is gone. The North-West furnishes small growths that would have been rejected by the lumberman 30 years ago. The South has reached its maximum production and begins to decline. On the Pacific coast only is there now any considerable body of merchantable standing timber. We are consuming yearly three or four times as much timber as forest growth restores. Our supply of some varieties will be practically exhausted in 10 or 12 years; in the case of others, without reforesting, the present century will see the end. When will we take up in a practical and intelligent way the restoration of our forests?" —*American Engineer and Railroad Journal.*

*

Coal Output in 1907.

THE Home Office Report on Mines and Quarries for 1907 shows that during the year a record output of coal amounting to 267,830,962 tons, valued at £120,527,373, was achieved. The increases, as compared with the previous year, were 16,763,334 tons and £28,998,112. The average price per ton rose from 7*s*. 7½*d*. in 1906 to 9*s*. in 1907. The quantity of coal actually shipped to foreign countries was 63,600,947 tons, or an increase of 8 million tons. France took 10·6 million tons and Germany nearly as much, Italy 8¼ million tons, the Netherlands and Sweden each about 3¾ million tons, Russia, Spain, Denmark, Egypt and the Argentine each over 2 million tons.

It will be seen that nearly a quarter of the total output was exported. This foreign demand was the cause of the high prices which railway companies and other home consumers had to pay for coal, and as a consequence, of the reduced railway dividends.

*

Anti-Corrosive Compositions.

MESSRS. Wailes, Dove and Co., Ltd., Newcastle-on-Tyne, have been awarded two Gold Medal Diplomas for their exhibits at the Franco-British Exhibition of "Bitumastic" enamels for the preservation of bridges and iron and steel structures generally, and also for ships. The firm received similar awards at Genoa '05, Milan '06, Savona '06 and Bordeaux '07.

*

Motor Railway Inspection Cars.

THE cars exhibited at the Franco-British Exhibition by the Drewry Car Co., Ltd., 13, South Place, Finsbury, E.C., have been awarded the Silver Medal Diploma. As we mentioned in our July issue, these cars have several especially good features which are peculiar to them, besides which they are made in this country.

Books, Papers, and Pamphlets.*

Earthwork Diagrams. By R. A. ERSKINE-MURRAY, A.M.I.C.E., and Y. D. KIRTON, A.M.Can.Soc., C.E. London: Crosby, Lockwood & Son.

These diagrams consist of a series of horizontal scales, well lithographed on a large sheet of paper, and afford a rapid method of ascertaining the volume of earthwork in embankments and cuttings. They will be found to be of much more ready use than are many of the ordinary tables.

Although it is not stated in the brief explanation given on the lithograph, we presume that the scales give the volume in cubic yards where levels are taken at each chain in the length of the longitudinal section. No indication is given as regards the formula that has been used, or whether, as the method only refers to level cross sections, the system of averaging the end areas and multiplying this by the length has been adopted. This should be stated in another edition, so that the engineer can give the proper value to the computation.

The contents found by the diagram therefore varies only with the heights given on the central or logitudinal section, the different shapes of the cross section, whatever they may be, not entering at all into the consideration. It is, however, not frequently found that the surface is level in the cross sections, and especially in the case where final or exact quantities are to be ascertained, it is not often that this too approximate basis can be used.

We do not see why so many different bases of formation width are dealt with, no less than sixteen to nineteen such bases being used for each different slope. If the bases of formation width for single and double lines of standard gauge had been adopted, together with the standard widths for narrow canals and turnpike roads, and if, instead of giving diagrams for only the three slopes of 1½ to 1, 1 to 1, and ¾ to 1, other diagrams for 1¼ to 1, 1¾ to 1, and 2 to 1 slopes had been included, the use of the scales would have been greater.

We also object to the limitation of the height of cutting or embankment, which is 24 ft. in the case of 1½ to 1 slopes, 31 ft. for 1 to 1 slopes, and 40 ft. in the case of ¾ to 1 slopes, and we cannot see why the earthwork should not be expected to be as high for the flatter as for the steeper slopes. These scales could have been extended for greater heights if a less number of bases had been dealt with.

Then, as most cross sections in actual work are on sloping ground, we should prefer another form of diagram where the three or five level system is adopted, and where the quantity or result required can be found by reading off

*For Books, etc., Received, see p. 382.

directly, instead of pricking off on a strip of paper, and applying this to a second scale for the reading.

For first approximate quantities of earthwork of the usual heights the diagram fully meets the case, and will be of great service.

Railway Accidents in 1907.

The General Report on Railway Accidents in 1907 issued by the Board of Trade shows that during the year only 18 passengers were killed in train accidents, and of these 11 were in the Shrewsbury derailment and three in the West Hampstead collision. The corresponding figures for 1905 were 39, and for 1906 they were as high as 58. The number of passengers injured in train accidents was 534, which has only once—in 1905—been lower since 1901. The number of servants killed in train accidents was 13—the same as in 1906, and these two years are higher in that respect than any since 1900. The number injured was 236, and this is very much higher than any year for which the return gives the figures. The apparent reason for this increase will be noticed when the figures as to accidents to employees by the movement of vehicles are considered.

A British railway train is still the safest place on earth, as only one passenger in 70 millions is killed, and one in every 2,300,000 injured.

It will not be out of place here to give the official figures for American travel as issued by the Interstate Commerce Commission Accident Bulletins for 1907.

TRAIN ACCIDENTS.

	Passengers		Servants	
	Killed.	Injured.	Killed.	Injured.
January-March	126	2,474	295	2,446
April-June	48	2,054	202	2,070
July-September	110	2,663	236	2,327
October-December	21	2,125	199	2,062
Total	305	9,316	932	8,905

The total "coupling" casualties for the year were 298 killed and 3,815 injured, and the total railway casualties amounted to 4,699 killed and 79,000 injured.

The total for British railways was 1,117 killed and 8,811 injured.

The collisions and derailments of goods and mineral trains and of light engines have now to be reported by the companies, and this has led to the figures for these jumping from 239 in 1906 to 994 in 1907.

There were 6 fewer passengers killed (102 in 1907 against 108 in 1906) by the movement of trains other than in train accidents. There was a decrease of 10 in the number killed whilst crossing the lines at stations, but an increase of 5 by falling between trains and platforms when entering trains, and an increase of 5 from falling out of carriages during the running of trains. During 1907 there were 2,132 passengers injured by the movement of trains other than in train accidents, against 1,949 in 1906—an increase of 183. Of these, 113 more were injured by the closing of carriage doors.

On December 21st, 1906, the Board of Trade made an order, one effect of which was that accidents on private sidings hitherto reported under the Factories Act were included in this return. All cases, too, had to be reported where an injury caused a man to be absent from duty for a whole day at any time. Previously it had only to be reported where the injured party was absent for five hours on any one of the three following days. These two amendments have thrown many more cases into the list, and it must also be remembered that during the year 1907 there was a great increase in the volume of traffic conveyed (there were 14 millions more miles run during 1907 than in 1906).

These explanations are necessary in order to account for the great increase in the number of servants injured by the movement of vehicles other than in train accidents, and they apply to the increase already mentioned in the number injured in train accidents. The injured under the former head numbered 4,225 in 1906, but it rose to 5,577 in 1907.

Enquiries are held by one of the two assistant inspecting officers, or the three sub-inspectors, into all serious accidents to servants, and in those cases where there would appear to be lack of supervision or irregular working. There were 891 such enquiries held during 1907, against 832 in 1906 and 789 in 1905. All accidents to servants caused by the movement of vehicles, other than in train accidents, are included under six headings, and the causes assigned by the above enquiring officers are similarly divided. The following is the result for 1907. The entries in the first column are those given by the inspectors, and in the second column those given by the companies when reporting the accident.

	Enquired into.	Not enquired into.
Misadventure or accidental	181	3,621
Want of caution or misconduct on part of the injured person	375	1,295
Want of caution or breach of rules on the part of servants other than the injured person	153	153
Defective system of working, dangerous places and conditions of work, &c.	82	6
Defective apparatus, want of appliances or safeguards, &c.	32	89
Neglect or non-observance of Rules under Railway Employment (Prevention of Accidents) Act, 1900	18	13
Total	841	5,177

From the foregoing it will be seen that out of the 6,018 casualties only 240 can be assigned to preventable causes, and what may be called the unpreventable outnumber the former by 24 to 1. A year ago the comparison was 16 to 1.

As accidents in coupling and uncoupling vehicles form a subject of interest, and even controversy, just now it is useful to give the figures of such, and to which we have added the returns for 1906.

	1906.		1907.	
	K	I	K	I
Coupling or uncoupling—				
with pole	3	264	3	363
without pole	2	66	7	96
screw-coupled vehicles	4	241	7	296
with automatic couplings	—	1	1	2
Total	9	572	18	757

The Report says that a large proportion of these injuries were due to men endeavouring to couple wagons by means of the pole before the vehicles had closed together, and that it is satisfactory to record that the majority of the larger companies have now adopted the suggestion of the Board of Trade, that the men should be warned against this practice. It is further remarked that two of the seven fatal accidents in dealing with screw-coupled vehicles occurred in connection with vestibule coaches. All of these accidents might have been avoided if the men had waited until the vehicles were at rest before attempting to go between them, and the Board of Trade believe that the number of non-fatal accidents would be materially reduced if instructions were issued by the companies to the effect that, wherever it can be avoided, the men must not attempt to go into the "four-foot" for coupling or uncoupling purposes while the vehicles are in motion. Such an instruction has been generally issued with regard to vestibule stock.

Another innovation in the Return has relation to the recommendations of the assistant and sub-inspecting officers. Instead of saying how many recommendations had been made, the figures for four years are given as below, and the percentage is an entirely new departure.

Year.	Total No. of injuries.	Total No. of recommendations.	No. of recommendations adopted.*	Proportion of recommendations adopted.
1904	717	306	219	71·6
1905	789	325	241	74·1
1906	832	352	269	76·4
1907	891	403	345	85·6

*At the time of the issue of the general report for the year.

It seems to us that further deductions might be made from this return. There were, it has been noted, 6,018

casualties to servants during 1907, and the Board of Trade (see above) made recommendations in 403 cases, or only 6·7 per cent.

The summary statement of accidents to trains, rolling stock, and permanent way at the end of the return is of no use for making comparisons in some respects, owing to the inclusions of the collisions and derailments of goods and mineral trains and light engines. All failures of couplings have now to be reported, so that these have jumped from 21 to 2,440.

Fires in trains rose from 19 to 170, and failures of machinery, springs, etc., of engines from 10 to 86, as the companies are now reporting all such.

The failure of tyres rose from 137 to 172, of axles from 148 to 160, of wheels from 1 to 8, and of broken rails from 264 to 289. It appears that of the 160 axles that failed 78 were crank or driving axles, and 6 of these were made of iron, and their average mileage was 373,624 miles, whilst the 72 steel axles had an average mileage of 294,589 miles. The report adds: "The average mileage of the iron axles that failed is due to the fact that axles are no longer made of this material. The few still in use are therefore of exceptional quality." Details of the type of tyres, axles, and rails that failed are given in the return, but we will not repeat these, as they are of the same proportions as those for the year 1906, quoted in *The Railway Engineer* for June last, page 178.

Sugg's New Station Lamp with Bijou Inverted Incandescent Mantles.

We illustrate herewith the latest and most improved gas lamp for lighting railway stations and other public places.

It will be seen, fig. 1, that the burner consists of a cluster of three (or, if required, two) inverted incandescent burners well spread apart. Large lamps are made with three clusters of three mantles each. By arranging the mantles in this way the area of the source of light is enlarged, and therefore the light is well diffused and shadows reduced to a minimum.

That the inverted incandescent mantle has a much longer life than the vertical mantle cannot be successfully disputed; it is much easier for a workman to handle. The small size of the mantles greatly increases their strength, and consequently their life, and therefore the general cost of maintenance is greatly reduced.

In consumption of gas the burner shows a very great economy. As compared with vertical mantles on burners of the most improved type, and giving a light of 100 c.p. on a consumption of 5 cubic feet per hour, the new burner with three small inverted mantles gives the same light, viz., 100 c.p., with a consumption of only 3½ cubic feet per hour, or an economy of 30 per cent. All these are important matters to railway companies, who are just now making great efforts to cut down working expenses in every direction.

Another great advantage of this burner is that it is supplied complete with reflector, as in fig. 2, ready to fix into existing lamps. The change is effected in a very short time, as there are only four small screws, which fix the reflector, to put in,

Fig. 1.—Sugg's Station Lamp, with "Bijou" Inverted Mantles.

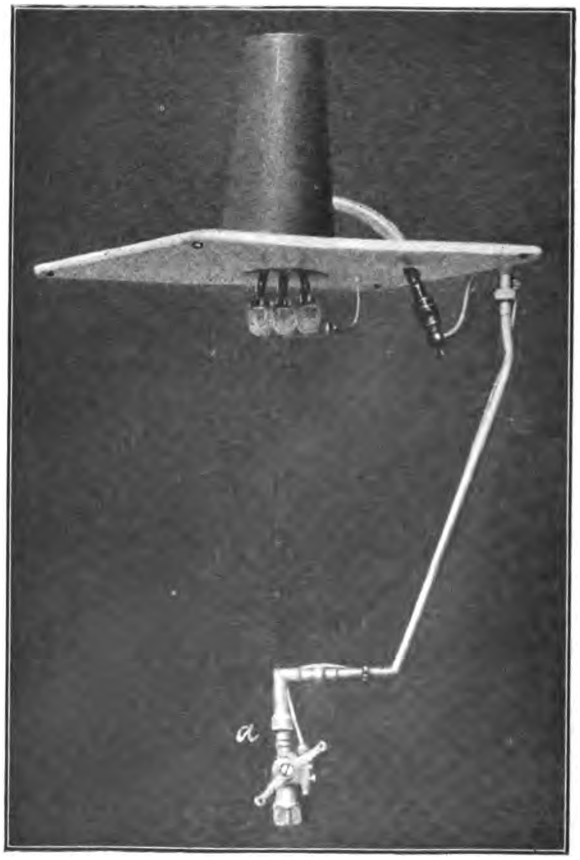


Fig. 2.

Fig. 3.

and the union *a*, fig. 2, for the gas supply pipe to connect, The burner is supplied either with or without the bye-pass, as may be desired.

It will be noticed that the screw regulating the admission of gas and the revolving shutter controlling the supply of air to the Bunsen are arranged in a top corner of the lamp under the reflector, where they are quite accessible and are always cool.

Another economy effected by this lamp is that the mantles do not require protectors, as vertical mantles do. These glass chimneys are a source of considerable expense to railway companies, as notwithstanding every care the consumption of them on a railway annually is very large.

We also illustrate, fig. 3, a special lamp, of which a number are being supplied to light a large bridge in the North of England, and on which, owing to the constant vibration and the exposed position, it was found impossible to get the vertical mantles to last any length of time. The new burner was tried, and as it gave complete satisfaction all the lamps are being altered. It will be noticed that these lamps are also suspended on the well-known "Devonport" attachment, which is the greatest mantle preserving appliance for station lighting that has ever been introduced. Except, however, for very exposed positions and places where there is great vibration and shocks, this attachment is not necessary with the new burner.

The burner is manufactured by Messrs. Wm. Sugg and Co., Ltd., Vincent Works, Westminster.

Notes on Swiss Locomotives.

For working the express trains on the Swiss Federal Railways four interesting series of locomotives have been introduced. They are all alike in the arrangement of the wheels, namely, six coupled, with a leading four-wheeled bogie, but in other important respects each series differs from all the others. They have all been constructed by one firm, namely, the Swiss Locomotive Works, of Winterthur.

We have mentioned that there are four series, but for the sake of distinction they can be arranged in two distinct types, according to the manner in which the power is transmitted to the wheels. The one has separate driving axles, whereas in the other type all the power is transmitted to one axle.

The first-named type is the more numerous class, in fact, one series may be regarded as a standard design, the variation from it in the other is mainly in the boiler. The type is illustrated by fig. 1.

The engines are four-cylindered compounds, with the H.P. cylinders outside driving the middle pair of coupled wheels. The valves are above the cylinders and are actuated by Walschaerts valve gear; the L.P. cylinders are under the smokebox, driving the leading coupled wheels. In this case also the valves are above the cylinders, but are actuated by Joy valve gear. All the valves are balanced slides. The leading axle is of the oblique crank form.

The engines have laminated bearing springs below the axleboxes, those for the leading and middle axles being connected by compensating beams. The bogies have inside frames, the spring gear is compensated, one spring being placed longitudinally between each pair of axleboxes, and connected at its ends to beams which rest on the tops of the axleboxes, the outer ends of the beams being linked to the frames. This is an unusual form of spring gear, and is not used in this country.

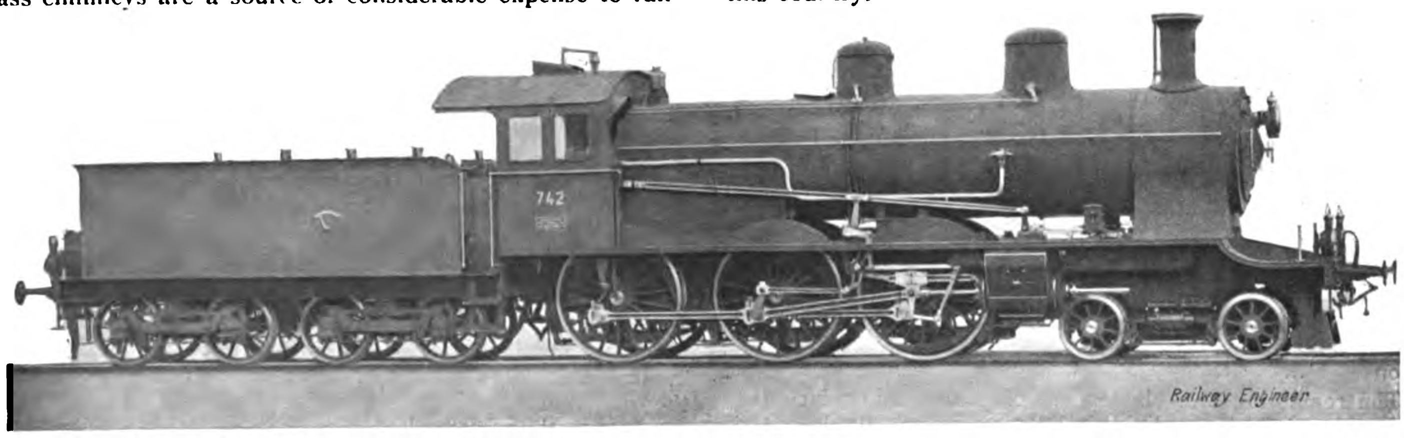


Fig. 1.

Fig. 2.

As regards the boilers there is no radical departure from accepted Continental practice for round-topped boilers. The staying of the firebox is direct, with the exception of the front end of the firebox, where articulated stays are introduced. The firebox back and fronts are sloped from the vertical so as to reduce weight at the rear end.

In the second class of the above-named type the main features, embracing the arrangement of the wheels and cylinders and accompanying details are identical with the engines just described, but in the boiler, however, a radical departure has been made, for in place of the ordinary type a combination of a watertube firebox with the usual form of barrel filled with tubes, known as the Brotan water-tube firebox, has been introduced. In the particular design under notice the water-tubes which constitute the front, back and sides of the firebox, enter at the top a single steam and water drum, which is connected direct to the back tube-plate of the barrel, the rear ring of which is coned, so as to provide a large tube-plate to accommodate the drum. At the bottom the tubes are stepped into a steel circulating ring, which also forms the foundation of the firebox. This ring is also connected by large circulating pipes to the underside of the rear end of the barrel. The vertical water-tubes are 95 *mm.* (3·74 in.) diameter outside, and 64 in number.

The above arrangement is simple to construct when compared with the earlier forms, in which the boiler was in reality two barrels super-imposed and connected at various points in their length, the top barrel extending over the grate and receiving the upper ends of the water-tubes. Another advantage is presented in the compactness, for the outside dimensions do not greatly exceed those of our ordinary firebox, while there is nothing to destroy the symmetry of the external appearance.

The annexed table gives the principal dimensions of the two classes :—

Class.	Fig. 1.	"Brotan" Boilers.
Cylinders, H.P. ...	14·2 in. x 25·9 in.	14·2 in. x 25·9 in.
Cylinders, L.P. ...	22·4 in. x 25·9 in.	22·4 in. x 25·9 in.
Wheels, coupled ...	5 ft. 10·4 in.	5 ft. 10·4 in.
Wheels, bogie ...	2 ft. 9·4 in.	2 ft. 9·4 in.
Wheelbase, rigid ...	13 ft. 7·8 in.	13 ft. 7·8 in.
Wheelbase, total ...	27 ft. 4·7 in.	27 ft. 4·7 in.
Boiler barrel, diam.	4 ft. 11 in.	4 ft. 11 in.
Boiler barrel, length	13 ft. 9·3 in.	14 ft. 5·6 in.
Pressure	220 lbs. per sq. in.	220 lbs. per sq. in.
Heating Surface		
Tubes	1,540 sq. ft.	1,710 sq. ft.
Firebox	166 sq. ft.	194 sq. ft.
Total	1,706 sq. ft.	1,904 sq. ft.
Grate Area	27·9 sq. ft.	26·9 sq. ft.
Weight Full, total...	63·3 tons.	64·1 tons.
Weight Full, adhesion	45·3 tons.	44·7 tons.

The remaining two classes are of the type in which the driving forces are not divided, but are concentrated on the leading coupled axle, the cylinder centre-lines being in one plane under the smokebox. The general features are illustrated by fig. 2. These designs, which differ in the abovementioned particulars, and also in outside appearance, have embodied several of the essential features of the other type, for instance as to the wheels and the capacity of the boilers.

The first of the two classes, represented by No. 601, are four-cylindered compound locomotives, fitted with a boiler containing a Schmidt type superheater; otherwise the boiler is of a similar design to the previously described engines. The pressure, however, is lower, 190 lbs. per sq. inch, in accordance with superheated steam practice.

Another seeming corollary to the use of this steam is the use of piston valves. These are actuated by the modified Walschaerts gear introduced by Von Borries, in which only one eccentric is employed for a pair of high and low pressure gears, but each cross-head is fitted with a separate lap and lead lever, the travel of the valves being communicated from the outer to the inner valve spindle cross-had by a rocking shaft.

The last class, and in some ways the most interesting, is based on the former as regards diameter of wheels, boiler and wheelbase, but possesses the vital difference of having three simple expansion cylinders, instead of four compounded, placed side by side under the smokebox and drive the leading coupled axle. The cranks are set at 120° with each other. The cylinders are all the same diameter, have piston valves actuated by Walschaerts valve gear. It is interesting to note that the difference in weight between the 4-cylinder compound and 3-cylinder simple is about two tons in favour of the simple engines. Their principal dimensions are :—

Class	4-cylindered.	3-cylindered.
Cylinders, H.P. ...	16·73 in. x 25·9 in.	18·5 in. x 25·9 in.
Cylinders, L.P. ...	24·8 in. x 25·9 in.	————
Wheels, coupled ...	5 ft. 10·4 in.	5 ft. 10·4 in.
Wheels, bogie ...	2 ft. 9·4 in.	2 ft. 9·4 in.
Wheelbase, rigid ...	13 ft. 7·8 in.	13 ft. 7·8 in.
Wheelbase, total ...	27 ft. 4·7 in.	27 ft. 4·7 in.
Boiler barrel, diam.	4 ft. 11 in.	4 ft. 11 in.
Boiler barrel, length	13 ft. 9·3 in.	13 ft. 9·3 in.
Pressure	190 lbs. per sq. in.	177 lbs. per sq. in.
Heating Surface		
Tubes	1,287 sq. ft.	1,287 sq. ft.
Superheater ...	404 sq. ft.	404 sq. ft.
Firebox	166 sq. ft.	166 sq. ft.
Total	1,858 sq. ft.	1,858 sq. ft.
Grate Area	27·9 sq. ft.	27·9 sq. ft.
Weight Full, total...	67·2 tons.	65·4 tons.
Weight Full, adhesion	44·7 tons.	44·4 tons.

From the above particulars it will be evident that the railway authorities have at their disposal four classes of engines based on similar lines, yet presenting most of the most modern principles. Thus they should be able to ascertain the relative efficiencies of the various designs : an opportunity not frequently presented.

Roofs.—XI.*

COMPRESSION MEMBERS (*continued*).

Mr. Wm. Cain, in the May proceedings of the American Society C.E., refers to Mr. Marston's formula, which is

$$\frac{P}{A} = \frac{S}{1 + \left\{(dV \div r^2) \sec. (\frac{1}{2}l \div r \sqrt{(P \div AE)})\right\}}$$

when S = the elastic limit, say 40,000 lbs. per sq. in. for mild steel columns with pivoted ends,

$dV \div r^2$ = 0·06 } for steel.
E = mod. of elas. 30,000,000 lbs.

$Vd \div r^2$ = 0·07 } for wrought iron.
E = 28,500,000 lbs.

and states that this closely follows the results of Tetmajer's test on columns, whilst for proportions of $l \div r$ of 125 and upwards it gives practically identical results with Euler's curve and the parabolic formula, and in lower values of $l \div r$ it agrees with the latter when the formula is useless. The other values are

P = load on column
d = the eccentricity or distance of load from axis of column
A = area of cross section
r = radius of gyration of the cross section about an axis through its centre of gravity perpendicular to the plane of bending
V = distance from this axis to the most compressed fibre

To apply this formula to the actual column $dV \div r^2$ is taken as 0·06 for steel and 0·07 for wrought iron, and assumed as constant.

l = length of column.

The same writer also suggests another rational formula of his own, which is

$$\frac{P}{A} = S \div \left\{\left(1 + \frac{dV}{r^2}\right) + \frac{1}{8E}\left(s - \frac{P}{A}\right)\frac{l^2}{r^2}\right\}$$

and in which S is the total fibre unit stress on the concave side of the column at mid-length, the other factors remaining the same as before, and the column being assumed to be pivoted at the ends.

T. Claxton Fidler's formula for the practical strength of columns is given as follows—

Minimum $p = (f + r - \sqrt{\{(f + R)^2 - 2{\cdot}4fR\}}) \div 1{\cdot}2$

where the

Maximum p or breaking weight of ideal column = R = $E\pi^2(r \div l)^2$

p = load in lbs. to produce stress f
f = ultimate compressive stress in lbs. per sq. in.
R = resilient force of ideal column in lbs. per sq. in.
L = length of columns in inches
For fixed ends $l = 0{\cdot}6\ L$
r = radius of gyration in inches measured in plane of easiest flexure
E = mod. of direct elasticity of material
= 26,000,000 for wrought iron
14,000,000 for cast iron
29,000,000 for mild steel
f = wrought iron 36,000 lbs.
cast iron 80,000 lbs.
hard steel 70,000
mild steel 48,000 lbs.
60,000 lbs. being a common average for steel.

Factor of safety = $4 + (\cdot 05\ l \div d)$

The eccentric loading of columns, where the load is applied on one side of the axis, or is supported on side brackets, should be considered and taken into account when necessary, and the formula to give an equivalent central load w, to be taken in place of the actual loading is as follows:

$$W_1 = \left\{W_1 + (xy \div r^2)\right\}$$

Where W = eccentric load
x = eccentricity or distance between load and neutral axis of column
y = distance between neutral axis and edge of section
r = radius of gyration = $\sqrt{(I \div A)}$

hence $r^2 = I \div A$, where I is the moment of inertia of section and A is the area of cross section.

This is in much the same form as that given by Adams for the maximum unit stress S.

$$S = s\left\{1 + x(yA \div 2I)\right\}$$

Where $s = W \div A$, and $1 \div r^2$ in the first formula is replaced by $A \div I$ in the second formula

Goodman, in "Mechanics Applied to Engineering," gives the following formula for the tensile stress in columns eccentrically loaded:—

$$f = \frac{W(y + S)}{Z} - \frac{W + W_1}{A}$$

Where f = the max. tensile stress on the material due to both direct and bending stresses
A = the sectional area of the column
W = eccentric load
W_1 = central load
y = eccentricity of the load
S = deflection or distance that the axis of the column is bent away from true vertical
z = modulus of section, that is, the moment of neutral axis of section from the most strained skin, usually half the depth of the section.

Merriman gives the following formula for a round ended column:—

$$S = \frac{P}{A}\left(1 + \frac{ac}{r^2} \sec. \tfrac{1}{2}\ Bl\right)$$

Where $Bl = l\sqrt{(P \div AE)} \div r$, in which case
S = the max. compressive unit stress on the concave side of the column; and
c = distance from the axis of the column to the concave side
P = load applied at
A = area of cross section of the column
a = the horizontal distance from the centre of gravity and in the same vertical plane with
r = the least radius of gyration.

If it is desired to find the value of $P \div A$ by successive trials when all the other quantities are given, the formula may be written

$$\frac{P}{A} = S \div \left\{1 + \frac{ac}{r^2} \sec. \frac{l}{2r}\sqrt{\frac{P}{AE}}\right\}$$

Another way of dealing with the question is by the use of the formula:

$$P = (W^1 \div A) + (M \div Z)$$

* The previous articles of this series appeared in the *Railway Engineer* as follows;—I., May, 1907; II., July, 1907; III., September, 1907; IV., October, 1907; V., December, 1907; VI., February, 1908; VII., April, 1908; VIII., June, 1908; IX., September, 1908; X., October, 1908.

Where P = safe unit stress
W^1 = safe eccentric load
A = sectional area of cross section
M = bending moment due to eccentric load, or WC, where W is the actual load and C the distance of this load from the centre of gravity of the cross section.

The latticing of compression members is another question that has only quite recently, in fact since the Quebec disaster, received any serious attention. Up to this the latticing has been merely arranged by rule of thumb or according to the caprice of the designer.

A simple way of ascertaining the stresses of lattice bars of columns is given by Professor Morris (see "Typical Steel Railway Bridges," by Thomson), and is as follows:

For single latticing on two sides of column,

$$s = i\,y \text{ sec. } x \div 2,$$

or for double latticing on two sides of column,

$$s = i\,y \text{ sec. } x \div 4.$$

Where s = stress in each lattice bar
i = increment of stress per lineal foot of column to be transmitted by the lattice bars.
i for pin-ended columns being

$$\tfrac{1}{2} Ad \div \tfrac{1}{2}l = Ad \div l,$$

or for fixed end columns

$$\tfrac{1}{2}Ad \div \tfrac{1}{4}l = 2Ad \div l.$$

A = area of cross section
d = difference between permissible average compression per sq. in. at centres of gravity of the whole section and that at the centre of gravity of either rib
$d = (p\text{-}p_1)\, x \div n$
p = permissible compression for short blocks = maximum outer fibre stress (say 16,000 lbs. per sq. in.)
p_1 = permissible average of comoression per sq. in. by column formula
x = distance from centre of gravity of cross section to centre of gravity of either rib
n = distance from centre of gravity of cross section to outer fibres
l = length of column in feet
r = radius of gyration
y = longitudinal distance in feet covered by one lattice bar
x = angle which the lattice bars make with the longitudinal axis of column.

This formula is arranged according to the argument that the permissible unit stress, if taken at the centre of gravity of the entire section, should be of such a value that the max. stress on the extreme fibres shall not exceed the unit stress allowable in a short block or column, or, in other words, that the unit stress at the extreme fibres shall be reduced from the unit stress of the short columns by the value of the unit stress due to the bending under load.

Assuming that the latticing is placed to connect two separate ribs, the function of such latticing is to transmit the difference in stress from one rib to the other; and as the unit stress in the rib is proportionate to its distance from the neutral axis of the whole section, or, speaking more definitely, of the distance of the centre of gravity of the rib from the centre of gravity of the whole section, then we may say that the lattice bars will have to transmit the difference between the average unit stress at the centre of the rib, and the average stress at the centre of the whole section of the compression member, of course multiplied by the area of the rib.

In the case of the pin ended column this stress is assumed to be transmitted in one half of the length of the column, and in the case of the fixed end column in one fourth of the length of the column, and the increment of stress per lineal foot is the total stress to be transmitted divided by such portion of the length.

The factor of safety to be taken in structures is given by Du Bois as follows for intermittent loading on sections other than hollow round.

Factor of safety = $4 + (l \div 20d)$ for wrought iron and steel
$7 + (l \div 20d)$ for cast iron
$6 + (l \div 10d)$ for timber

When l = length in inches
d = least side of rectangle which encloses the cross section,

Whilst for hollow round sections,

Factor of safety = $3 + (l \div 10d)$ for wrought iron
$6 + (l \div 10d)$ for cast iron

and for quiescent loading we are to use 4 for wrought iron, 6 for cast iron.

So far as railway work at least is concerned the cast iron column is now practically superseded by the steel beam section of stanchion, and it seems probable that before long this again will be abandoned in part in favour of the reinforced concrete column.

Winn (Royal Engineers' papers) says that although concrete has great power to resist compression, the power is greatly increased if about 1 per cent. of longitudinal rods are added to resist any tension due to the bending of the column, and if 2 per cent. of wire be wound round the vertical rods in the form of a spiral, with spaces of about $\frac{1}{8}$ the diameter of the member between the turns, the bursting of the column under pressure will be prevented, and the concrete column reinforced in this way will bear about four times the load of the same column when not reinforced. The figure given is from 900 to 1,000 lbs. per sq. in. with safety.

The following points were mentioned in a discussion on this subject before the American Soc. C.E. in February last. The hooping, if properly applied, increases the breaking strength of a concrete column to two or three times that of the simple column. The surface of the concrete outside the hooping will begin to crack at about the breaking load of the column if not hooped, and the hooping, if not continuous or rigid, will peel off with the surface concrete, and becomes useless for strengthening.

Talbot, in Bulletin No. 10 of the Illinois Engineering Station, calls attention to the fact that reinforced concrete columns very seldom have a height exceeding one fifteenth of the diameter, and this is usually less, especially in the lower storeys of high buildings. He also states that the tested difference in strength between a column of five diameters long and one of fifteen diameters is often less than the difference in strength between columns of the same length.

Kahn, before the Liverpool Engineering Society, gives the formula for ordinary reinforced concrete stanchions as follows, with the proviso that the length shall not exceed 15 times the least diameter:—

Safe load $= c\ (A^c \div 15\ A^s)$

Where c = value of concrete in compression, say 1,000 lbs. per sq. in. for spirally reinforced columns

A^c = area of the concrete

A^s = area of the steel in compression.

The tension in the hoop per sq. in. of height for 1,000 lbs. stress on the concrete is $32{\cdot}5d$

and $a = 32{\cdot}5\ dp \div s$, or $p = sa \div 32{\cdot}5d$.

Where a = section of hoop

d = diameter of core in inches

p = pitch of hooping in inches, which should not exceed $d \div 6$

s = alllowable stress on the hoop, say 24,000 lbs. per sq. in.

Considere gives the following formula for the strength of a short hooped column:

$$C = 1{\cdot}5c + 2{,}400p + 5{,}100p^1$$

Where C = unit strength of the column in lbs. per sq. in.

c = unit strength of a plain concrete column

p = ratio of longitudinal reinforcement to the concrete core

p^1 = ratio of the hooping to the concrete core

Talbot, in No. 20 bulletin, gives a general form of formula for hooped columns as follows:

$$c = c^1 + pc^{11}$$

Where c = max. strength of the hooped column

c^1 = strength of the plain concrete column

c^{11} = coefficient for the hooping

p = ratio of reinforcement found by dividing the total volume of the hoops by the volume of the core within the hoops, in other words, by considering the hooping to be distributed as a thin cylinder continuously along the hooped column

Values are given as follows for the column reinforced with bands:

$$C = 1{,}600 + 65{,}000p$$

and for spiral reinforcement:

$$C = 1{,}600 + 100{,}000p$$

In the discussion on reinforced concrete construction before the Boston Soc. C.E., in 1906, the following formula is presented:

$$C_1 = C\ \left\{(1 - p) + rp\right\}$$

Where C_1 = unit pressure upon reinforced column

C = unit pressure upon the concrete of the column, usually 400 to 600 lbs. per sq. in.

E_s = mod. of elas. of steel

E_c = mod. of elas. of concrete

$r = E_s \div E_c$, usually ·1 to ·5

A = area of total cross section of the column

A_s = area of steel in the cross section

$p = A_s \div A$, usually ·01 to ·04

Tedesco gives the Hennebique method of calculation of columns as:

$$P = 344\ C + 13760R$$

Where P = safe load in lbs.

C = sectional area of concrete in sq. in.

R = sectional area of longitudinal reinforcement in square inches

and taking $R \div C$ as a percentage, say ·01, we have

$$P = 344C + 137{\cdot}6C = 481{\cdot}6C$$

$$\text{or } C = P \div 481{\cdot}6 \text{ if } R = C \div 100$$

Considere has also given another formula:

$$S = 0{\cdot}45\ (1 + 32\ p + 15\ p_1) \div 100$$

Where S = safe load in tons per sq. in. of spiralled section

p = the percentage of spiral rod

p_1 = the percentage of longitudinal rods to unit volume of concrete

The Report of the British Joint Committee on Reinforced Concrete recommend the following:

The reinforcement of columns should in general amount to at least 0·8 per cent. of the gross cross section. Columns should be spirally bound and the distance between the coils should not exceed $\frac{1}{10}$ to $\frac{1}{6}$ of the diameter of the spiral.

Then for a load strictly axial

$$c = P \div \left\{A_c + (m - 1)\ a\right\} = P \div A$$

$$t = mP \div \left\{A_c + (m - 1)\ a\right\} = mP \div A$$

Where A_c = the cross section of the column, including the reinforcement

A = equivalent section

a = the section of the longitudinal reinforcing bars

P = load on the column in pounds

c = stress on the concrete, usually 500 lbs. per sq. in.

t = stress on the steel, usually 7,500 lbs. per sq. in.

m = ratio of the coefficients of elasticity, usually 15 for columns less than 18 diameters in length.

(To be continued.)

Locomotive Journals and Bearings.—VIII.*

Lancashire and Yorkshire Railway.

THE Lancashire and Yorkshire R., being a net work of lines connecting important towns, and for the most part serving densely populated districts with important junctions at frequent intervals, and colliery or factory sidings joining the lines almost every few hundred yards, the engines are not required, and have not the opportunity of making long non-stop runs, but they are required to make continual and successive spurts and to get away very quickly, or, in other words, they must be able to exercise to the full all that is expressed by "that blessed word acceleration."

In the season the L. and Y. railway has concentrated on to its extreme west (mainly Southport and Blackpool) not only from its own system, but from all parts of the country, an excursion traffic unequalled in magnitude by any other in the country. It is not uncommon for 40,000 excursionists to be delivered in Blackpool before 8 a.m. These excursion trains are often of great length and weight, and follow each other in rapid succession westwards in the morning and eastwards in the evening. They must not be delayed and neither must the ordinary service, as the whole district served by the system is essentially a commercial one, and the L. and Y. averages a greater train mileage per route mile than any important railway in the world. The curves are numerous and sharp, and so are the gradients, and among the latter the well-known Accrington Bank, 1⅜ miles of 1 in 40, and the Turton Bank, 4½ miles of 1 in 74, may be cited.

The L. and Y. route between Liverpool and Manchester —36½ miles—is the longest, but its trains do the trip in the

* Previous articles of this series in February, March, May, June, July, August and October, 1908.

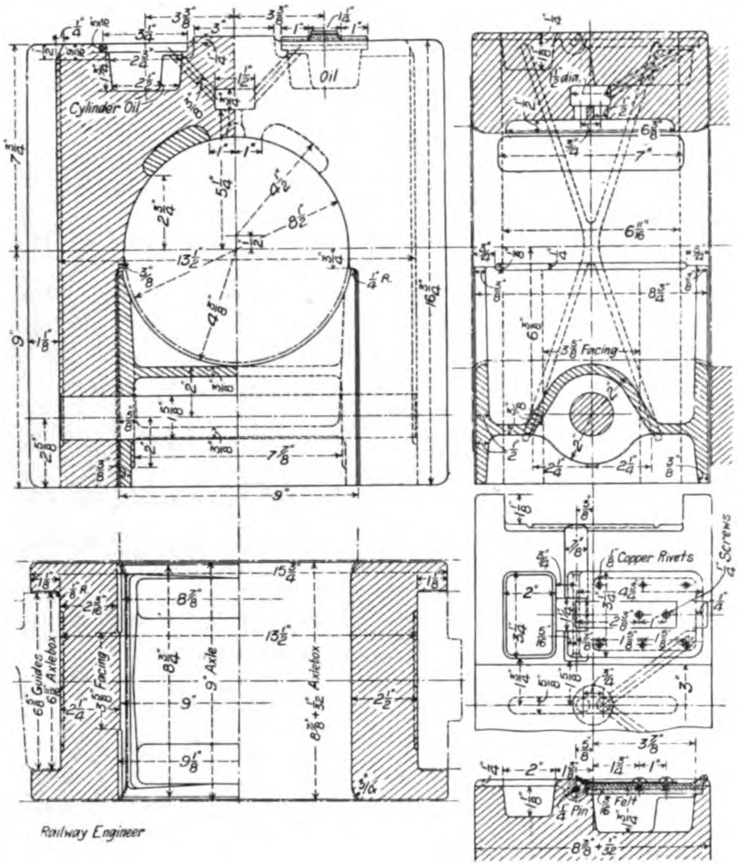


Fig. 35.—Driving Axle-Box; Lancashire and Yorkshire Railway.

same time—40 mins.—as the other two competing companies. The 35 miles between Manchester and Southport are covered in 45 mins. with two intermediate stops; Manchester to Brighouse, 34 miles in 40 mins.; Manchester and Blackpool, 48¾ miles in 65 minutes. Other instances might be given, but the above are sufficient to indicate the principal characteristics of the traffic for which the engines have to be designed and which explain why the engines might, to a casual observer, seem to be unnecessarily powerful.

For this work Mr. J. A. F. Aspinall, the general manager of the line, when he was chief mechanical engineer, designed a class of very powerful inside cylinder engines with a 4-4-2 wheel arrangement, and having the following dimensions:—

Cylinders, 19 ins. by 26 ins.

Wheels—bogie, 3 ft. 0⅜ in. diam.; coupled, 7 ft. 3 in. diam.; trailing, 3 ft. 7⅝ in. diam.

Heating surface—tubes, 1,877 sq. ft.; firebox, 175·8 sq. ft.; total, 2,052·8 sq. ft.

Great area, 26·05 sq. ft.

Wheel base, 27 ft. 9 in.

Weight, total in working order, 58 tons 15 cwt., distributed as follows:—On the bogie, 12 tons 5 cwt.; on each of the coupled axles, 17 tons 10 cwt.; on the trailing axle, 11 tons 10 cwt.

Capacity of tender for water, 2,290 galls.; for coal, 5 tons.

The details illustrated belong to these engines, and we are indebted to Mr. Geo. Hughes, M.Inst.C.E., the present chief mechanical engineer, for the drawings of them.

Driving Axle-Box, fig. 35. This box is made of gunmetal. It is 8$\frac{29}{32}$ in. long, the journal being 8½ in. diam. by 9 in. long. It is 13½ in. wide between the horn faces and 7¾in. deep from the top to the centre. On each side of the centre line there is a white-metal inset having wearing surfaces about 2½ in. by 7 in. The horn surfaces are 6$\frac{11}{16}$ in. (horns 6⅝ in.) x 16¾ in. The bearing is carried down at the sides ¾ in. below the centre-line, but is eased away as shown to allow the film of oil off the under pad to be drawn round by the journal.

The oil from the top is admitted to the bearing along the crown by means of a trough 6⅝ in. by ½ in. deep. Two oil boxes are cast in the top of the box and are fitted with spring corners lined with felt, as shown. From these boxes the oil feeds through ⅜ in. holes to a cavity cored out 1½ in. diam. by ¾ in., and from there through two ¼ in. holes to the trough

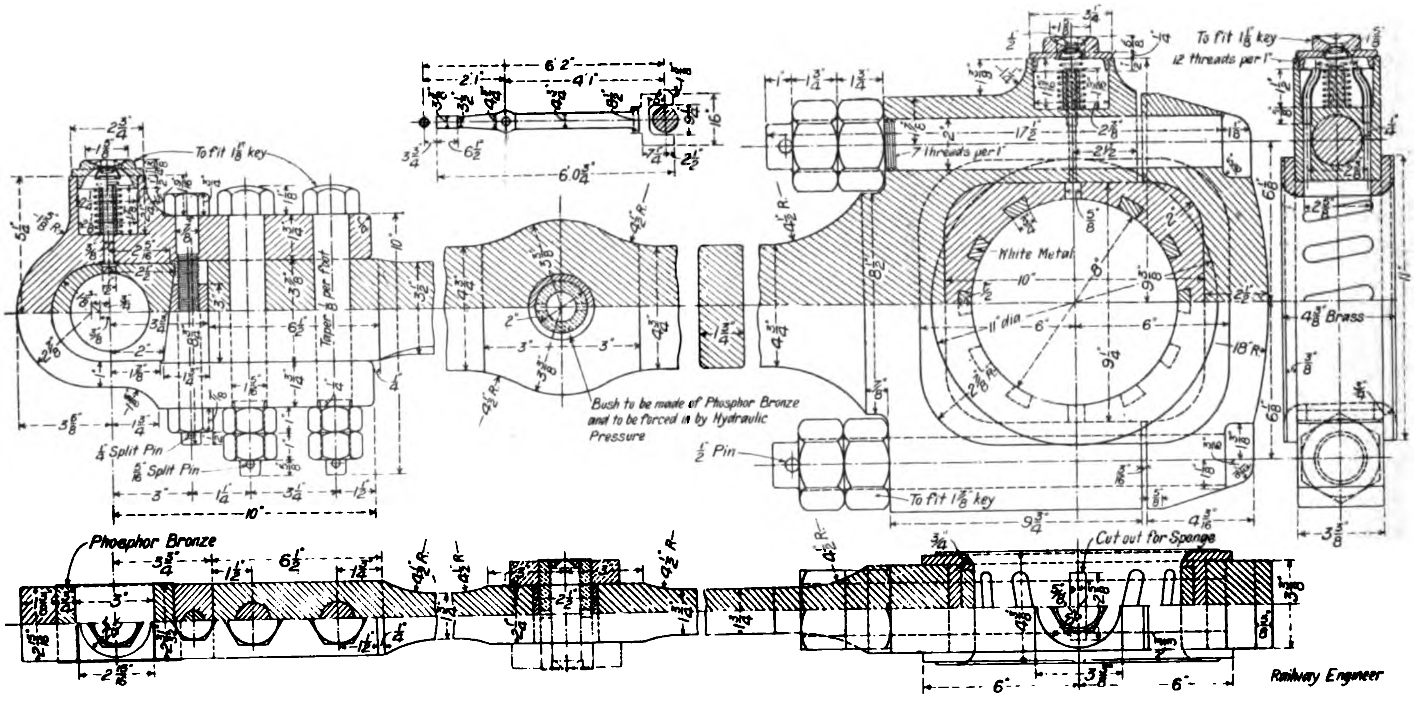


Fig. 36.—Connecting Rod; Lancashire and Yorkshire Railway.

above mentioned. The axle-box carries a load of 8·75 tons.

The Keep, which fits tight up to the bearing at the ends, is made of cast-iron and contains a lubricating pad. It is supported on the spring-link pin, which is of wrought iron $1\frac{5}{8}$ in. diam.

causes an addition of metal on the connecting-rod where one would prefer not to have it in a quick-running engine.

The Big-End is of the bolted type, but it differs in detail from all the three others we have illustrated. The rod is $3\frac{3}{8}$ in. thick, and is forked to receive the brasses which have

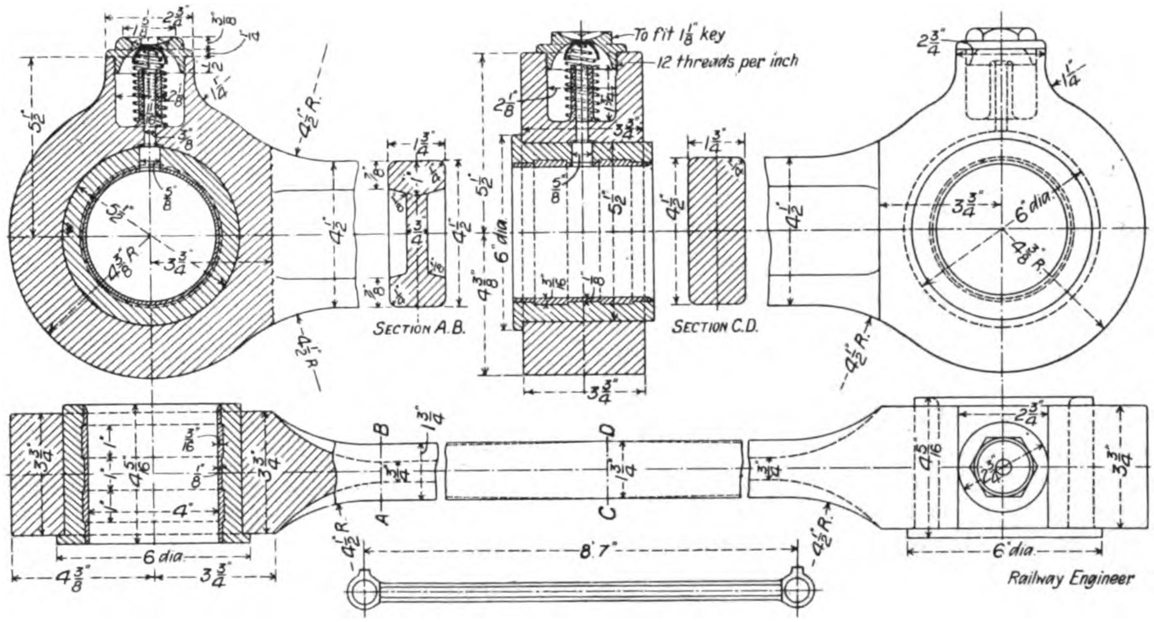


Fig. 37.—Coupling Rod; Lancashire and Yorkshire Railway.

Connecting Rod, fig. 36. This rod is for 10-wheeled 4-6-0 inside cylinder engines. It is 6 ft. 2 in. long between the centres, and is made of forged steel. The section of the rod is rectangular with the corners rounded off to a radius

flat seats 10 in. long by $9\frac{1}{4}$ in. with the corners rounded to a 2 in. radius. The bearing is 8 in. diam. by $4\frac{3}{8}$ in. long, and is fitted with five white-metal insets dovetailed in, as shown in each brass. The Keep, which is of steel, has a middle

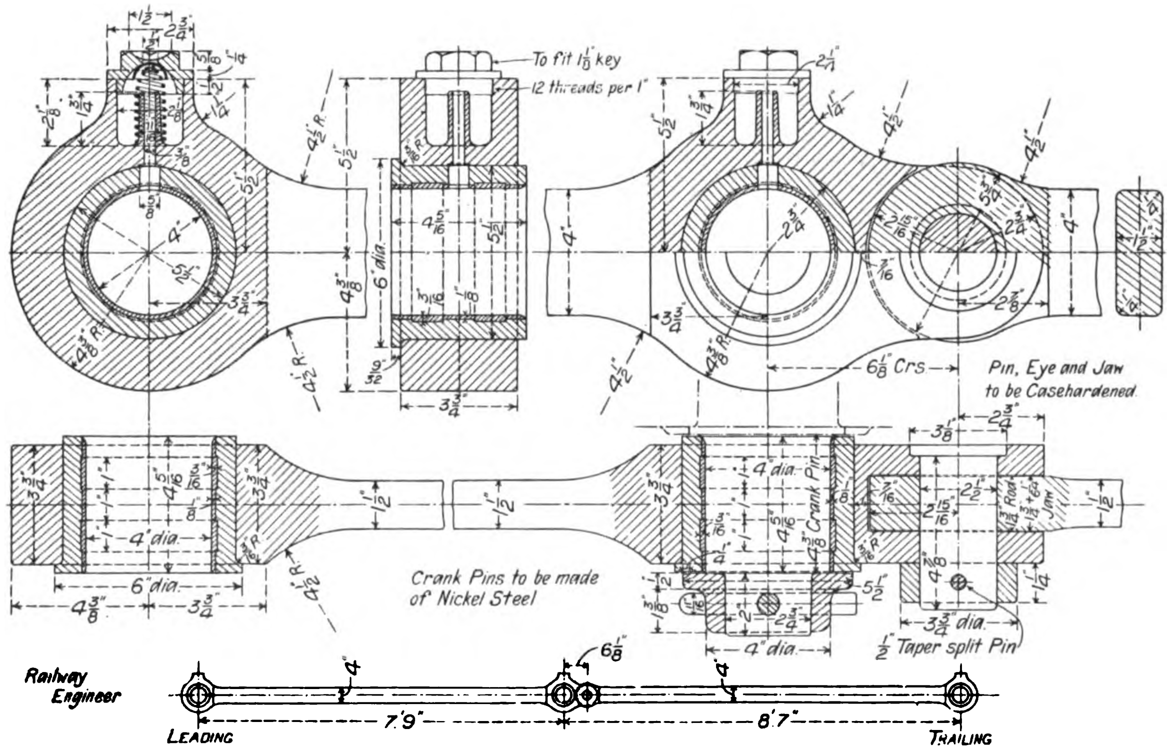


Fig. 38.—Coupling Rod; Lancashire and Yorkshire Railway.

of $\frac{1}{4}$ in., and is parallel $4\frac{3}{4}$ in. by $1\frac{3}{4}$ in. from the big end to the middle boss, then it tapers to $3\frac{1}{2}$ in. by $1\frac{3}{4}$ in. The boss is necessitated by the connection for working the Joy valve gear, and it is one of the disadvantages of that gear that it

section of $2\frac{1}{2} \times 3\frac{3}{8}$, and is secured by two wrought-iron bolts 2 in. diam. fitted with double nuts, each $1\frac{3}{4}$ in. thick, and a split safety pin $\frac{1}{2}$ in. diam., the heads of the bolts are square, $1\frac{1}{8}$ in. thick, bedded into the Keep as shown.

The oil cup ($2\frac{3}{4}$ diam. by $1\frac{9}{16}$ inside) is cut out of the solid just over the centre, and fitted with a brass cap screwed in. The feed-hole is closed with a spring button. The oil holes are $\frac{1}{4}$ in. diam. and lead to the ends of a recess $\frac{3}{8}$ in. by $2\frac{3}{8}$ in. the brass over the centre of the bearing, there being a similar recess exactly like it under the centre of the bearing.

For the middle bearing, for the stirrup link pin, the rod is swelled to a depth of $6\frac{3}{4}$ in. by $2\frac{1}{4}$ in. A phosphor-bronze bush $2\frac{1}{2}$ in. diam. outside is pressed in by hydraulic pressure. The bearing is 2 in. diam. and is lubricated from the inside, the pin being hollow and closed at the ends with brass screwed plugs, as shown.

The butt end of the rod is $6\frac{1}{2}$ in. long by $3\frac{3}{8}$ in. by $2\frac{15}{16}$ in., and the small-end bearing is attached to it by a steel strap ($1\frac{3}{8}$ by $2\frac{15}{16}$ at the bend) fastened by two wrought-iron bolts tapered from $1\frac{5}{16}$ in. diam. at $\frac{1}{8}$ in. per foot, and fitted with double nuts, 1 in. thick, secured by $\frac{5}{16}$ in. split pins. The Bush is of phosphor bronze, and has a bearing 3 in. diam. by $2\frac{31}{32}$. The halves of the bush are set up by a mild steel wedge threaded on a $\frac{7}{8}$ in. bolt, locked by a nut secured by a $\frac{1}{4}$ in. split pin shown.

The oil cup is solid with the strap, and is fitted in a similar way to that on the big-end bearing.

Coupling Rod, fig. 37. These are made of nickel-steel, and are 8 ft. 7 in. long between the centres. They are parallel, being $4\frac{1}{2}$ in. deep by $1\frac{3}{4}$ in. thick. The middle section is solid, but the sides are gradually milled out to I section, the web at the ends being $\frac{3}{4}$ in. thick and the heads $\frac{7}{8}$ in. deep as shown, the outside corners are rounded off to a $\frac{1}{4}$ in. radius and the inside fillets are $\frac{1}{8}$ in. radius.

The eyes are struck with a $4\frac{3}{8}$ in. radius and are $3\frac{3}{4}$ in. wide. They carry cast-iron bushes $5\frac{1}{2}$ in. diam. pressed in tight and lined with white-metal $\frac{1}{8}$ in. and $\frac{3}{16}$ in. thick. It will be noticed that the bushes are not keyed in any way and that the white-metal is the full width of the bearing, which is 4 in. diam. by $4\frac{5}{16}$ in. long, the journal being $4\frac{3}{8}$ in. long. The oil-cups are bored out of the solid $2\frac{1}{4}$ in. diam. by $1\frac{3}{4}$ in., and are closed by a brass cap screwed in with 12 threads per inch; the feed-hole in the centre is closed with a spring button. The oil-hole is $\frac{3}{8}$ in. diam., and leads to a $\frac{3}{8}$ in. hole through the white-metal-lined cast-iron bush.

Fig. 38 illustrates the coupling rods of the standard 6-coupled tender goods engines, of which the cylinders are 18 in. by 26 in.; wheels, 5 ft. 1 in. diam.; wheel base, 16 ft. 4 in.; total heating surface, 1,209·94 sq. ft. (of which 1,102·26 sq. ft. are in the tubes); grate area, 18·75 sq. ft.; total weight 42 tons 3 cwt., distributed as follows:—13 tons 16 cwt. 2 qrs. on the leading axle, 15 tons on the driving axle, and 13 tons 6 cwt. 2 qrs. on the trailing axle; capacity of tender tank, 1,800 galls.; coal, 3 tons.

It will be seen that the bearings on these rods are very similar to those of the express engine. The knuckle joint has a wrought-iron case hardened pin $2\frac{1}{2}$ in. diam. secured by a washer and $\frac{1}{2}$ in. split pin. The jaws of the joint are also case hardened.

(To be continued.)

Scientific Lightning Protection on Railways.

Differences of opinion still prevail concerning the best methods of guarding against lightning, as is only natural when one remembers how varied are the conditions which govern the requirements between one type of building and another and even between two buildings of the same type.

The difficulty is also increased because of the anomalous behaviour of lightning itself. Thus instances have been known where lightning had penetrated the strongest casement walls, and yet left unconsumed powder lying in a loose condition close by; or where a house had been struck by lightning causing fire at a railway booking office more than half a mile distant. Indeed, it has sometimes been urged by those who lack precise knowledge of lightning and its effects that this force, unlike every force in nature, is erratic—not governed by law and even prone to act in violation of it. Such a view is of course unscientific and untenable.

In the discussion following Sir Oliver Lodge's paper before the Institute of Electrical Engineers, the late Lord Kelvin, referring to the Professor's suggestion "that common galvanized iron telegraph wire be run up all the corners of a house, along all the ridges and eaves, and over all the chimneys, taking them down to the earth in several places," said:—

> "Multiplying the mains by connecting a large number of comparatively small wires, instead of one close conductor, does seem to me to be an important practical suggestion. I would take these galvanized iron wires—and the more of them the better—down all the corners and wherever they can be got, and connect every one of them to a water pipe. I would connect all pieces of metal to each other and to a water main if the latter is available; if not connect them to the lightning conductor and give *it* a good earth."

Prior to his lamented death Lord Kelvin was the greatest authority on electrical science, and the inference to be drawn from the foregoing pronouncement is that an installation of lightning conductors should be an approximation to a metallic cage since a building so protected is perfectly immune from danger. It happens, however, that the majority of railway engineers, without questioning the accuracy of his Lordship's opinions, not unreasonably object to the disfigurement of stone tracery and other portions of architectural ornamentation by the presence of a mesh of iron telegraph wires, which in five or six years time would be sufficiently oxidised as to require renewal.

Furthermore the expense and inconvenience of connecting all pieces of metal together and the whole of them to earth would be considerable; in the case of a large goods warehouse it would be prohibitive.

The question naturally arises, is it not possible, without sacrificing efficiency, to modify the before mentioned system, so that its several parts will not be unduly prominent? The answer is in the affirmative and many illustrations could be given did space permit. In the modified system referred to copper would be used throughout as the conducting medium on account of its greater durability. A careful examination would be made of all the metals in the building, keeping the system clear of those that cannot be connected, maintaining a respectful distance from all gas pipes, metallically uniting those metals which it is expedient and safe to do so, and making connections across gaps where harmful sparking would be liable to occur. It is along these general lines that reliability may be ensured even though it entails a greater mental effort.

If a conductor fails (and this rarely happens, according to the best information) it is due to an oversight of the scientific aspect of the matter and invariably might have been prevented at the expenditure of a few shillings.

In order to better understand the principle at issue the fact is worth recalling that lightning conductors serve a two-fold purpose. 1st, if a building is struck, the current passes to earth through the conductor instead of through the masonry or brickwork, thus protecting life and property. 2nd, it also tends to prevent disruption by neutralising the opposite charge of electricity in the thunder cloud to that induced upon the surface of the earth below it. As evidence thereof a brush shaped discharge may be occasionally seen at the final aigrette on a summer night. Thus a lightning conductor discharges functions similar to those of a safety valve which enables the steam to escape from the boiler before it has attained an explosive pressure therein.

If, however, the thunder cloud becomes suddenly electrified by a flash from a higher cloud there is no time for the

brush discharge to act and a flash is inevitable. Whether a conductor will prove effectual in safely conveying to earth the current at such a dangerous tension depends upon the manner in which the system has been installed; or in other words, whether strict attention has been paid to the danger zone of a lightning flash. Experience has shown that after all roof projections in the vicinity of lightning conductors have been put in communication with the latter lightning has diverged from the prescribed path and caused as much damage by lateral discharge as would have occurred by a direct lightning stroke. This lateral discharge or "side flash," as it is technically described, forms one of the greatest dangers of a badly planned installation, and indicates that the lightning has found a better conductor in a neighbouring gas pipe, or along some lead flashing, than is afforded by the lightning rod.

The solution to the question of what constitutes the danger zone and what metal work should or should not be metallically united with the conductor system can scarcely to set forth in tabular form; it must be decided by local circumstances based upon experience and a more than superficial knowledge of the business, as is the rule in other departments of railway administration.

Assuming that the work has been carried out in accordance with the laws which are known to govern the subject there yet remains two important matters which ought not to be overlooked.

I. The necessity for periodical inspection.

II. The value of a good earth.

I. *The necessity for Periodical Inspection.*—This implies a close study of the conditions existing from time to time in a building. A conductor system may have been installed in a perfect manner; it may have been tested regularly twice per year, and the resistance, compared with previous readings found unaltered, and yet in the meantime some alteration to gas or water supply pipes, inside or outside the structure, may have been made which has rendered the system inefficient notwithstanding the satisfactory tests. These faults can only be discovered by a periodical inspection and a careful consideration of the problem in its altered phase. That this is no fanciful theory unsubstantiated by fact the following incidents will clearly prove.

(*a*) In a certain goods yard the Agent gave orders for a sleepered stage to be built for the reception of petroleum casks. Unfortunately the vacant site selected was beside the warehouse wall, down which the main-lightning conductor was cleated. A cursory examination showed that any of the iron hoops encircling the casks could have been inadvertently left in metallic contact with the copper tape. As soon as the grave risk of fire involved by such a procedure was pointed out the petroleum casks and sleepered stack were removed to a less dangerous situation with commendable promptitude.

(*b*) A chimney conductor, on being tested, offered a resistance of 6·9 ohms. Visiting the place some time later a gas pipe was found stapled to the chimney at right angles to and in contact with the copper rope. This gas pipe led to a wood-built shed containing inflammable stores. If the conductor had been struck the shed would probably have taken fire, since a gas "earth" measures but the fraction of an ohm and lightning takes the path of least resistance. The route of the gas pipe was diverted.

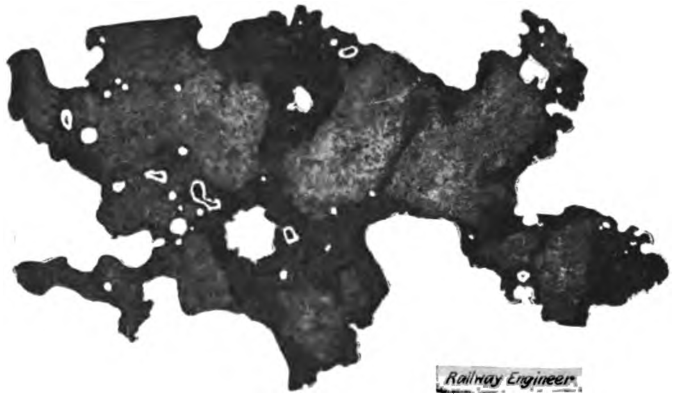
(*c*) An iron fire escape was installed at the gable end of a five-storeyed goods ware house, the top portion of the ladder projecting six feet above the slated roof. Within two feet of the fire escape a lightning conductor and also a 4in. fire hydrant pipe were fastened to the wall near the same vertical line. Such an undesirable combination would have led to a lateral discharge; nay more, the fire ladder was more likely to be struck than the conductor because of its greater height. The danger was eliminated and the efficiency increased by connecting all three together top and bottom by a substantial metal band.

II. The Valve of a good Earth.—In his valuable treatise on lightning guards Sir Oliver Lodge affirms that "a good earth is desirable chiefly to prevent damage to gas pipes, foundations and other things buried therein; also, secondarily, to keep down the total obstruction to the discharge and lessen the tendency to side flash as far as may be. No earth can prevent a tendency to side flash, but a bad earth may aggravate that tendency unnecessarily." Wherever possible it is desirable to attach the lower end of the conductor metallically with the town water main, not merely by winding it several turns round the pipe, but also by soldering, and that too with solder capable of permanent sojourn in damp earth. Should there be two conductors to a chimney the latter can be made exceedingly safe by connecting one to a water main and the other to a copper plate buried in damp sub-soil.

The resistance of a water main "earth" rarely exceeds 0.5 ohm, whilst that of copper plate immersed in soil water usually measures one or two ohms. No earth should be considered satisfactory which registers more than 12 ohms, for the simple reason that with good workmanship it is quite an easy matter to keep within that figure of merit. But it must not be assumed that a conductor, perfect in other respects, would fail to perform its proper function if the resistance was higher than the figure quoted. One instance is remembered where a building similar in some respects to an "American skyscraper" was subjected to severe lightning flashes yet the conductor did not fail at the crucial moment notwithstanding that its resistance measured several hundred ohms. This of course is not a safe criterion.

What is the best kind of material to distribute about the ground plate in order to obtain excellent results? The list is usually set forth in the following order:—

1st, charcoal; 2nd, coke; 3rd, carbon; 4th, natural earth. With reference to charcoal, the worst that can be said against it is that of expense; and further, if generally used the demand would exceed the supply. Coke is not to be recommended because of the sulphur contained therein and its injurious effect upon the copper plate. The destruction of



Corrosive effect of a copper earth plate embedded in coke.

the latter, embedded in coke, is a very real and serious matter. Through the kindness of Mr. Alfred Hands, the eminent London expert, an illustration is given herewith showing the effect upon a plate originally $\frac{1}{16}$in. thick taken up after being about a dozen years in coke. The sample is typical of many others.

The choice then lies between carbon and natural earth, and in view of the excellent conductive properties of the former it is far preferable to the latter. Railway companies are in the unique position of having a plentiful supply of carbon for all requirements. Instead of throwing the unconsumed pieces of arc lamp carbons to the scrap heap or ballast train they can be collected in barrels at the various electric light depôts and consigned when full to whatever locality the authorities may decide. On certain lines the work of lightning protection is relegated to contractors; still, a clause could be inserted in the specification enforcing the use of scrap carbon (about 6 bushels per hole) to be supplied by the railway company in every case.

Railway buildings are admittedly vulnerable, but it is a

matter for congratulation that a locomotive cab and the interior of a railway carriage are almost lightning proof. Should a flash strike either it would find such a ready escape through the metal frame work to the rails and to earth that danger would seldom occur; fires never. And this is the reason why passengers experience no discomfiture during a thunderstorm. The worst that could happen to an engine driver supposing his hand were upon the regulator at the moment of a heavy discharge would be a slight sensation—absolutely harmless—consequent upon the surging or wave-like effect of the current.

Meteorologists tell us that thunderstorms are gradually increasing over the whole of Europe; if that be so, every advantage ought to be taken of the fuller knowledge which modern science has revealed in relation to the phenomena of atmospheric electricity and of the best methods of guarding against its dire effect.

Portable Stone Breaking Plant.

The annexed illustrations show a portable stone-breaking plant which has recently been constructed to the requirements of Mr. Wm. Roberts, M.Inst.C.E., chief engineer of the Highland R., and to whom we are indebted for the following particulars.

Fig. 1 shows the complete plant. The stone-breaking machine itself was made by Messrs. Goodwin, Barsby and Co., of Leicester, and is similar to their "Acme" Portable Automatic Stone Breaker illustrated by fig. 2. It has a cubing motion, only one toggle plate, and gives two distinct blows for each revolution.

The stone is fed through a mouth 16ins. by 9ins. and, when broken, passes into the lower screen which separates the small and chippings. The remainder passes on to an elevator belt, which is armour-plated and provided with an improved tightening arrangement, and is raised into the upper screen, which parts it in 1in. and 2½ins. sizes into bins or out through the chutes. Any larger pieces travel out at the end of the screen and fall direct into the mouth of the machine.

Fig. 1.—Portable Stone Breaking Plant.

The plant has been mounted by Mr. P. Drummond, the locomotive, carriage and wagon superintendent, on a steel underframe, details of which are given, by that gentleman's courtesy, in fig. 3. It is 45ft. long over the headstocks, 8ft. 6in. wide, and is carried on two bogies, which are 32ft. apart, centre to centre.

The engine is a 16 B.H.P. Hornsby oil engine, with lamp ignition, and enclosed in the brake-compartment, 20ft. 2½in. long, which also contains a comfortable room, 5ft. long, for the engineman's use when stationed at outlying places. This

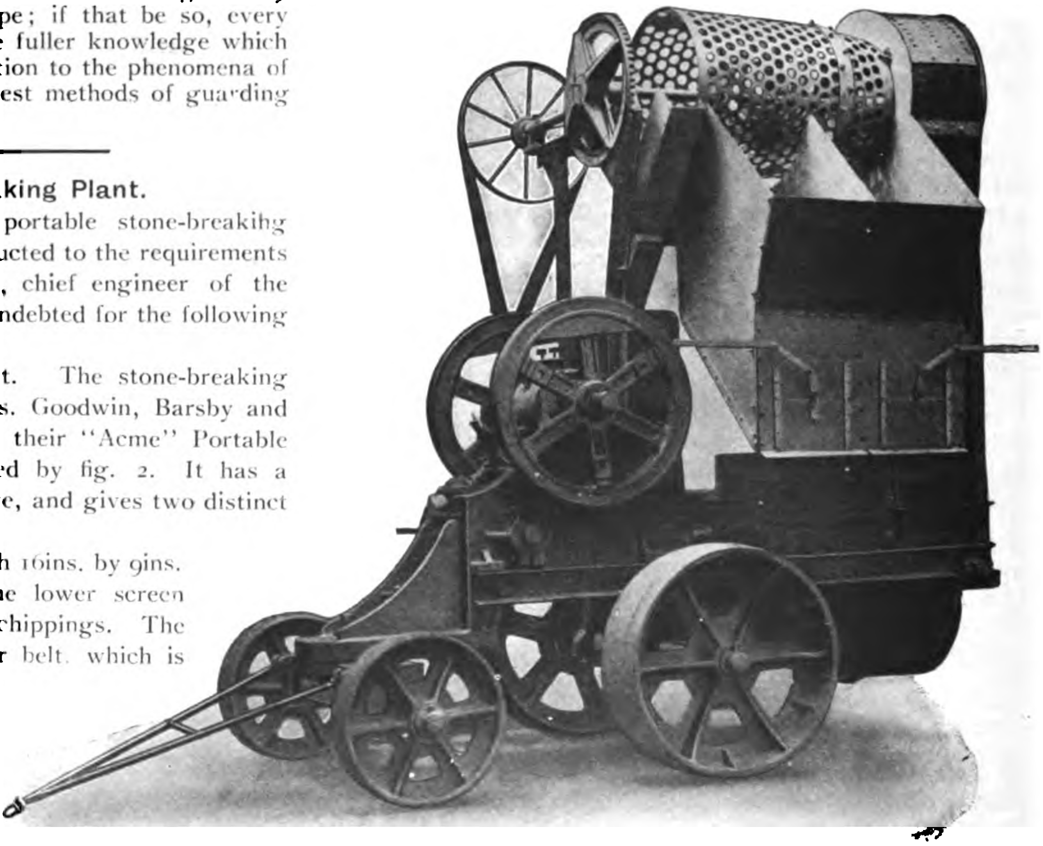


Fig. 2.—"Acme" Portable Automatic Stone Breaker.

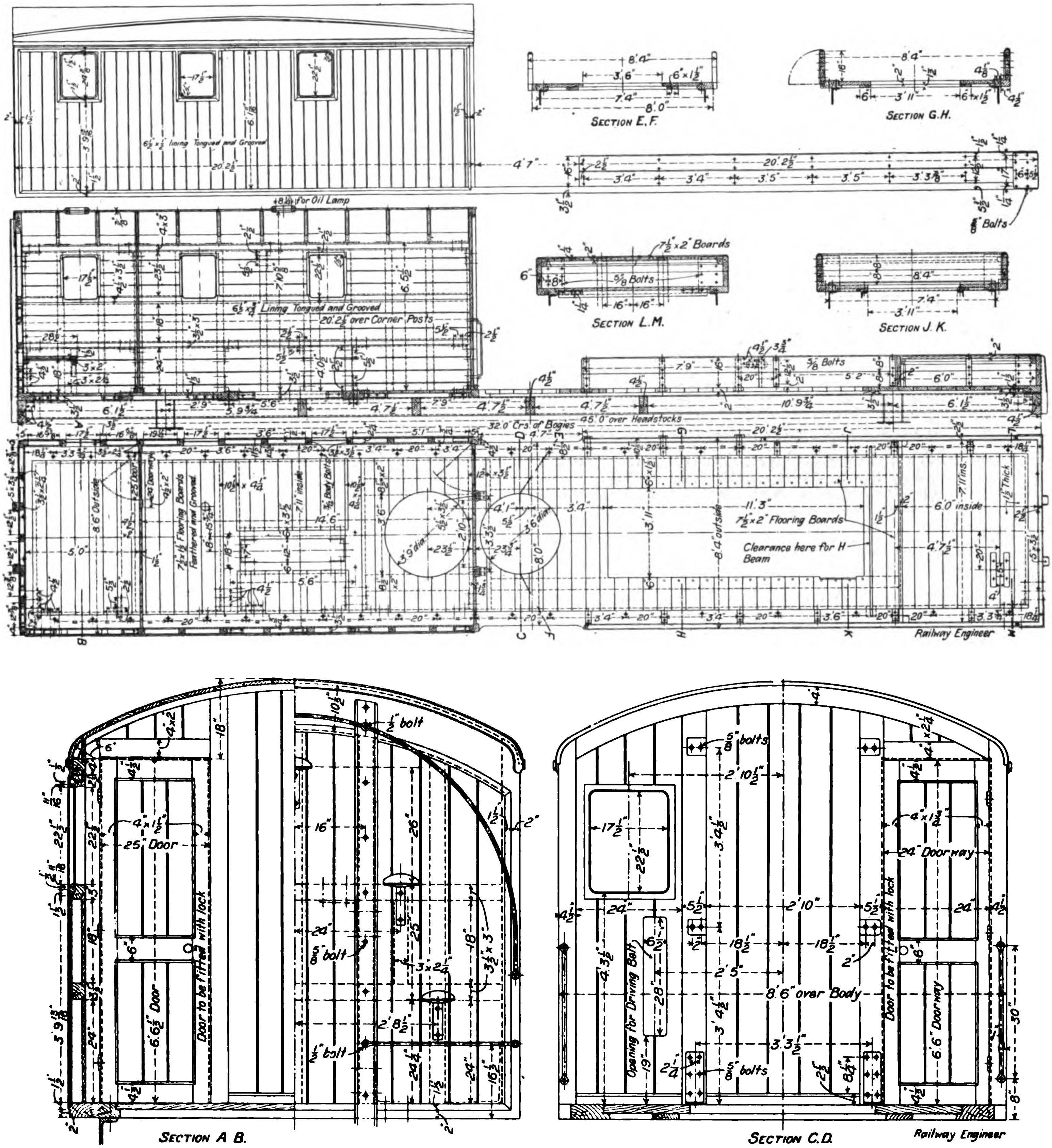


Fig. 3.—Portable Stone Breaking Plant.

room has a berth for the engineman across the end, also a table and cooking stove. This accommodation is necessary as the object of the plant is to place it in a siding and break ballast from borrowing pits and rock cuttings. Suitable stone is found there, especially in the higher lying portions of the Highland Railway.

The plant had to be put together with some care so as to clear the loading gauge. The chutes are collapsible, of special design, and will feed into wagons standing on adjacent roads, yet when raised for travelling they clear the structure gauge.

Central South African Railways, 1907.

The Annual Report of the general manager of the Central South African Railways states that during 1907 248¾ miles were opened and 143½ miles taken over, bringing the total mileage up to 2,409.

The revenue and expenditure compared with the figures for 1906 were :—

	1907. £	1906. £		£		%
Revenue—						
Passengers	1,093,333	1,157,244	—	63,911	or	5·51
Parcels	83,381	102,034	—	18,653	,,	18·35
Goods	1,826,060	2,239,954	—	413,894	,,	18·50
Coal	868,536	911,234	—	42,698	,,	4·69
Live Stock	82,928	92,060	—	9,132	,,	9·92
Miscellaneous	185,393	279,523	—	94,130	,,	33·60
Total	4,139,631	4,782,049	—	642,418	,,	13·40
Expenditure—						
Working	2,011,154	2,163,571	—	152,417	,,	7·06
Renewals Fund ...	356,281	680,710				
Special	1,941	34,432				
Total	2,369,376	2,878,713				
Balance	1,770,255	1,903,336				

The working expenditure amounted to 48·6 per cent. of the gross earnings as against 45·2 per cent. in 1906. If the amounts set aside for depreciation of capital assets be included, the percentage is 57·2 against 60·2 in 1906.

The train mileage of 6,323,158 shows a reduction of 678,862 miles or 9·7 per cent.

The goods traffic, 4,686,888 tons, hauled during 1907 shows an increase of 26,599 tons as compared with 1906, while a reduction of nearly 10 per cent. in the train mileage has been effected, notwithstanding that the average open mileage operated has increased by 254 miles.

The total through goods traffic, inland and coastwards combined, shows a decrease of 71,528 tons as compared with the previous year. The tonnage forwarded to the coast colonies increased by 72,549 tons, but the traffic received from the coast colonies shows a falling off of 144,077 tons. The tonnage included in this last figure in respect of general goods only (*i.e.*, the balance remaining after deducting the figures in respect of coal for the public and for railway use) is 107,935 tons, made up as follows :—C.G.R. Ports, —29,095; N.G.R. Ports, —40,163; Lourenço Marques, —34,365; other C.G.R. Stations, —8,875; other N.G.R. Stations, +4,563. The shrinkage in the traffic from the ports alone amounts to 103,623 tons or 16 per cent., and as this general traffic from the ports constitutes by far the most profitable portion of the carrying trade the reason for the substantial reduction in the goods earnings will be apparent. While it is not improbable that as the country becomes more prosperous this shrinkage will be arrested—at all events for some years—yet there has for some time past been every indication of an altered condition of affairs in South Africa generally and in the inland colonies particularly in regard to the transport of oversea goods as compared with the internal or local traffic of the two colonies.

In striking contrast with the reduced tonnage of traffic received from the coast colonies is the increase in the traffic forwarded to the coast colonies. In general goods (including produce exports) this traffic shows an increase on the figures for 1906 of 38,293 tons (64 per cent.), made up as follows :—To Cape R., 7,097; to Natal R., 20,362; to Lourenço Marques R., 10,834.

Three instances are quoted for the purpose of explaining the loss of oversea long-haul traffic :—

(1) Time was when the bulk of the dynamite and other explosives, of which so large a quantity is used in the Transvaal, was imported ready manufactured from oversea, for the conveyance of which profitable railway rates were charged. Now the bulk, and very soon practically all, the explosives will be manufactured in South Africa from raw material cheaply imported and carried at low railway rates. It has further been established that it is possible, if needs be, for all the explosives to be manufactured in the Transvaal. During the year 1907 2,403 tons of manufactured explosives were imported into the Transvaal from oversea, and 5,511 tons from the Cape.

(2) In the half-year ending 31st December, 1905, the weight of candles imported from oversea into the Transvaal was 3,807 tons, in the year 1906 it was 6,179 tons, and in the year 1907, 3,561 tons. There were also received from the Cape during the two and a half years 906 tons of candles. The probability is that during the next and following years the importation of candles from oversea into the Transvaal will be practically unknown, and that it will be left to the railways to carry the raw materials required for the manufacture of the candles in the Transvaal (whether such raw materials are obtainable in South Africa or imported from oversea) at the greatly lower railway rates naturally charged for such classes of traffic.

(3) In the half-year ending 1905* the weight of cement imported (which was also carried at profitable railway rates) into the Transvaal was 20,176 tons; in the year 1906, 25,343 tons; and in the year 1907, 14,957 tons. Cement is now being manufactured in the Transvaal (from raw materials obtained locally and carried by rail for short distances and at low rates) of such a quality and even standard that it promises to displace imported cement in ordinary use almost entirely. It has already done so to a very considerable extent.

These three illustrations are cited as cases where the course of railway transport has been altered without the aid of preferential railway rates. In each instance the volume of traffic affected is considerable. In quoting these particular cases it is not the desire to suggest that industries should be created or maintained by such artificial aids as preferential railway rates. On the contrary, the purpose is to show the effect on railway revenues of the establishment of local factories and industries and the necessity that has already arisen for the revision of the methods of railway rating so as to correspond with the changed conditions of trade. The necessity for such revision is particularly urgent in the case of the C.S.A.R., by the reason of the short distance which local traffic is carried on the average. As already mentioned, the tonnage of local coal for public use (which is included in the lowest tariff) was 2,473,349, or 61·4 per cent. of the total public traffic (through and local) carried. Of this, 940,000 tons approximately was carried for distances under 51 miles. Of the remainder, about 1,170,000 tons was carried for distances between 51 and 100 miles, leaving only 363,000 tons to be carried to all places distant over 100 miles.

Similarly with other local public traffic, which amounted to 454,015 tons. Approximately 110,780 tons was carried under 26 miles, 118,498 tons from 26 to 50 miles, 93,981 tons from 51 to 100 miles, 66,286 tons from 101 to 150 miles, and only 64,470 tons over 151 miles. It is to be remembered that the terminal services have to be rendered at both ends by this Administration in the case of local traffic. Such terminal services cost the same, whether the traffic has to be carried 10 miles or 1,000 miles. There is the further expensive consideration that, in order to secure economical working, the engine runs must be as long as is reasonably practicable. It is not usually practicable, when detaching trucks at stations short of engine runs, to replace them by others, and under such circumstances (which are very common in working short distance traffic) trains travel for the remainder of the distance short of the full engine load. Of course arrangements are made to keep such expensive working at a minimum, but all the same considerable wastage necessarily occurs in handling such short-haul traffic.

In addition to the tree-planting at the Government Farm near Pan Station, of which there still remain about 500 acres to be planted—making a total of 2,115 acres—a commencement has been made with tree-planting operations on the farm "Jessievale," east of Breyten, by arrangement with the Agricultural Department of the Transvaal, who are undertaking the work of cultivating 381 acres as a first instalment on behalf of the Administration. A commencement has also been made with tree-planting in the Orange River Colony on the farm "Imperani," in the Ficksburg district. Good progress has been made with the 214 acres authorised. The following varieties of trees are being grown :—Eucalyptus Microtheca, E. Rostrata, E. Sideroxylon, E. Tereticornis, and mixed Conifers.

Steps have been taken to extend the workshops at Pretoria and Bloemfontein, and to obtain the necessary additional machinery—so far as was absolutely essential. The extensions of the workshops at Pretoria and Bloemfontein which were decided on, so to admit of any carriages and wagons required being built in the country, are nearing completion. In the meantime so much carriage and wagon building as was possible with the accommodation and machinery available was undertaken during the year.

In view of the constant and lengthened controversies regarding the merits of the several routes and South African ports for the conveyance of traffic to and from the inland centres in the Transvaal and the Orange River Colony, Mr. J. Conacher, formerly general manager of the Cambrian and of the North British R., assisted by Mr. Fiddian, North-Eastern R., was appointed to investigate and report on the matter. His report has been published. While it contains little that was not previously known and accepted as being the general position by other than partizans, the report is of especial value in emphasising so forcibly that

***Note.—The reason for the figures for the last six months only being given for the year 1905 is that it is the period given in the Customs Bureau Statistics.**

under existing conditions trade route disputes must, from the nature of things, be expected, and that the only satisfactory solution of the problem lies in the amalgamation of all the railways and harbours under one administration and authority. Further, that the combined railways and harbours must be administered solely from the point of view of transport purposes, and that the revenue derived should be applied solely to railway purposes, including, of course, payment of interest on the capital outlay. All who have had any extended experience in dealing with the complex issues involved, whether colonial, commercial, or official, will entirely share Mr. Conacher's conclusions in this respect.

The employment of white (in place of native) labour on piecework, on new construction platelaying has been continued during the year without adding to the expenditure. The practicability of earthworks being efficiently carried out by white labour on piecework at no greater cost than was paid to contractors employing native labour has been already established in the two Colonies, and when railway building is resumed, it is proposed to arrange accordingly. Such work is congenial and is sought after by white men who have become accustomed to it. At one time there was some difficulty in inducing the men to seek the platelaying and ballasting work in the past, but during the building of the Bloemfontein-Kimberley railway the men gave the platelaying work a trial on piecework, appliances suitable for handling the rails having been provided by the Administration. The work was arranged in detail by the engineer in charge, and the men soon got interested in it. Moreover, the emulation of the men working together in the several sections gave zest to the employment. The result was entirely satisfactory both to the men and to the Administration. Much credit is due to Mr. Jack, the engineer in charge of the work, and to Mr. Wall, the chief engineer, for the personal interest he has taken in making the experiment a success. The endeavour to get the ballasting of the line done by white labour was not so successful. The work is laborious and uninteresting, and in consequence a portion only was done by white labour on piecework, the greater part being done by natives.

The distress among the poor whites became so acute that urgent application was made on their behalf for work on which natives were employed in goods sheds, station yards and elsewhere, even if they were only paid at the same rate of wages as the Kaffirs were receiving. With the need for economy and the falling revenue, it was impossible to pay appreciably more than the work was worth and was actually being done for by native labour. An offer was, however, made that if a lesser number of whites undertook to perform efficiently between them the work done at Volksrust by the natives, the difference in pay would be divided between them.

The experiment at Volksrust proving successful, it was extended, and at the close of the year about 300 whites were employed on various classes of work which has hitherto been generally regarded as only justifying the employment of Kaffirs.

Since the beginning of the year several hundreds more indigent whites have been employed on the same class of labour.

It is too soon to determine yet whether the experiment will prove successful, *i.e.*, whether the indigent whites will continue in any numbers in permanent railway employ on the present terms, and, if so, whether they will become efficient at the work they are engaged to perform.

With a view to giving the experiment a thoroughly fair trial, to remove any misunderstandings on either side, and to adjust any difficulties where possible, the company have engaged the services for a time of Mr. Bredell (who is well known to the workers) inspector of white labour. This appointment has proved beneficial in various ways.

A most satisfactory record in respect of native labour has been established during the period under review.

The average monthly number employed during 1907 was 7,916 as against a monthly average during 1906 of 9,495. This reduction has been effected in spite of increased mileage, and points to the attention that is being given to obtaining efficiency, and that better work is being done with a smaller number of natives.

Forced Lubrication for Axle-Boxes.*

By Mr. T. HURRY RICHES, President I.Mech.E., and Mr. BERTIE REYNOLDS, Taff Vale Railway.

This Paper describes a system of Forced Lubrication as arranged for the driving axle-boxes of some of the steam-cars of the Taff Vale R. Before entering into a detailed description of the system used, it will perhaps be advisable to give a few of the more necessary particulars concerning these cars.

The engine is carried on a four-wheeled truck of 9ft. 6in. wheel base and 2ft. 10in. diameter wheels, the boiler (of double-ended locomotive type, lying transversely across the frame) being placed immediately over the centre of the leading or driving-axle.

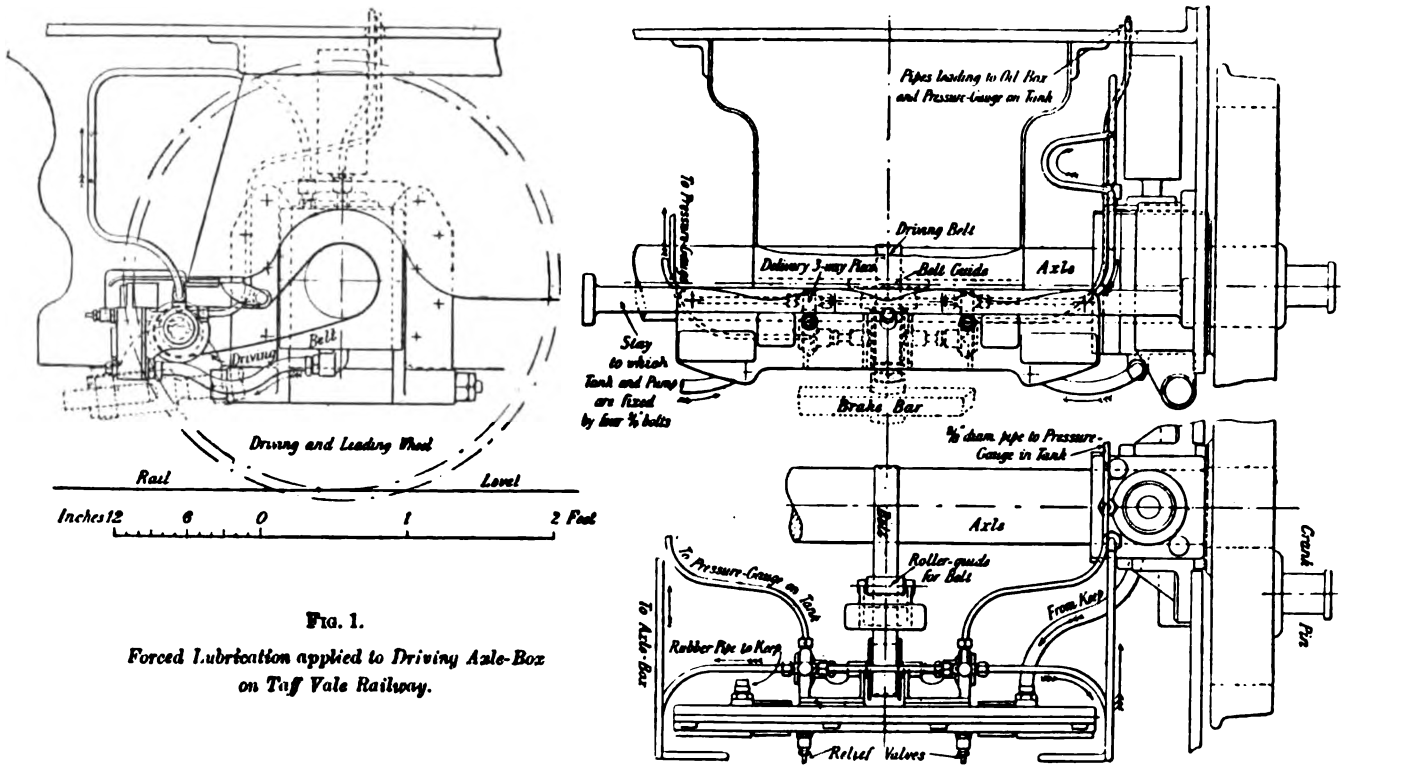


FIG. 1.

Forced Lubrication applied to Driving Axle-Box on Taff Vale Railway.

The front end of the coach is supported by means of a bogie centre, carried between the frames at a distance of 4ft. from the trailing-axle, or 5ft. 6in. from the leading-axle. When the car is loaded with its full complement of passengers, the weight on the driving-axle is 15 tons 13 cwts., the weight at the rail being 17 tons 6 cwts. The journals are 6in. diam. by 9½in. length; therefore the pressure, taking two-thirds of the projected area of the brass as bearing area, is 466 lbs. per sq. in., the number of the revolutions of the journal, at a speed of 30 miles per hour, being practically 300. With this pressure and high rubbing

*Read before the Institution of Mechanical Engineers.

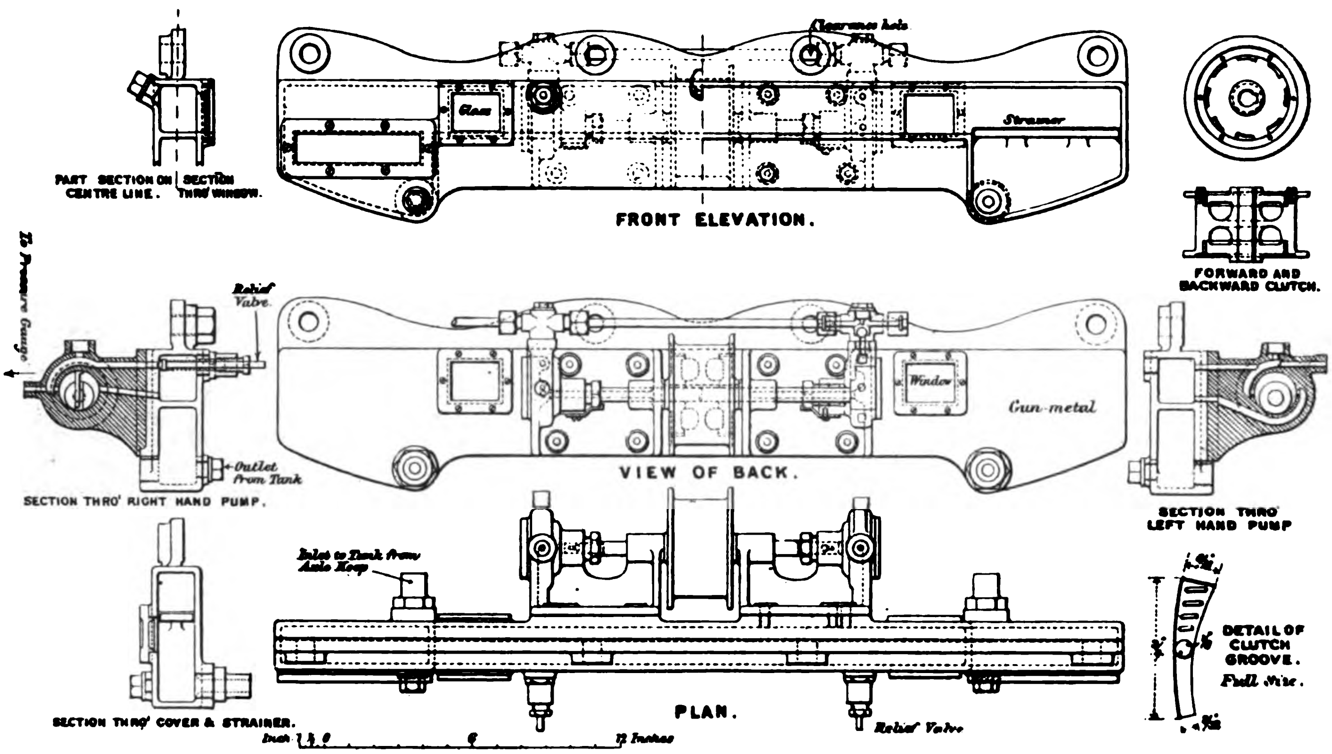


Fig. 2.—Oil Tank and Pump for Steam-Car on Taff Vale R.

velocity an undue amount of oil was being used with the ordinary method of lubrication, while cases of the bearings running hot were not infrequent, therefore the following arrangement for lubricating the journals under pressure was adopted.

To a cross-stay in front of the driving-axle, fig. 1, a small gun-metal tank of rectangular section, fig. 2, is fixed. On the side of this tank, nearer the driving-axle and in connection with the tank, two small rotary pumps—right and left-handed—are fitted,

Following the process through, for the lubrication of one of the journals, when the car is in motion, oil is pumped from the tank and forced through a coiled copper pipe to the top of the axle-box, fig. 3. An oil channel, $8\frac{1}{4}$ in. long, $\frac{3}{16}$ in. deep, is cut in the crown of the box, leaving a margin of metal at each side of the channel of $\frac{3}{8}$in. flat, which is found, when the box is properly bedded to the journal, to be quite sufficient to ensure that it shall be perfectly oil-tight at the pressures attained.

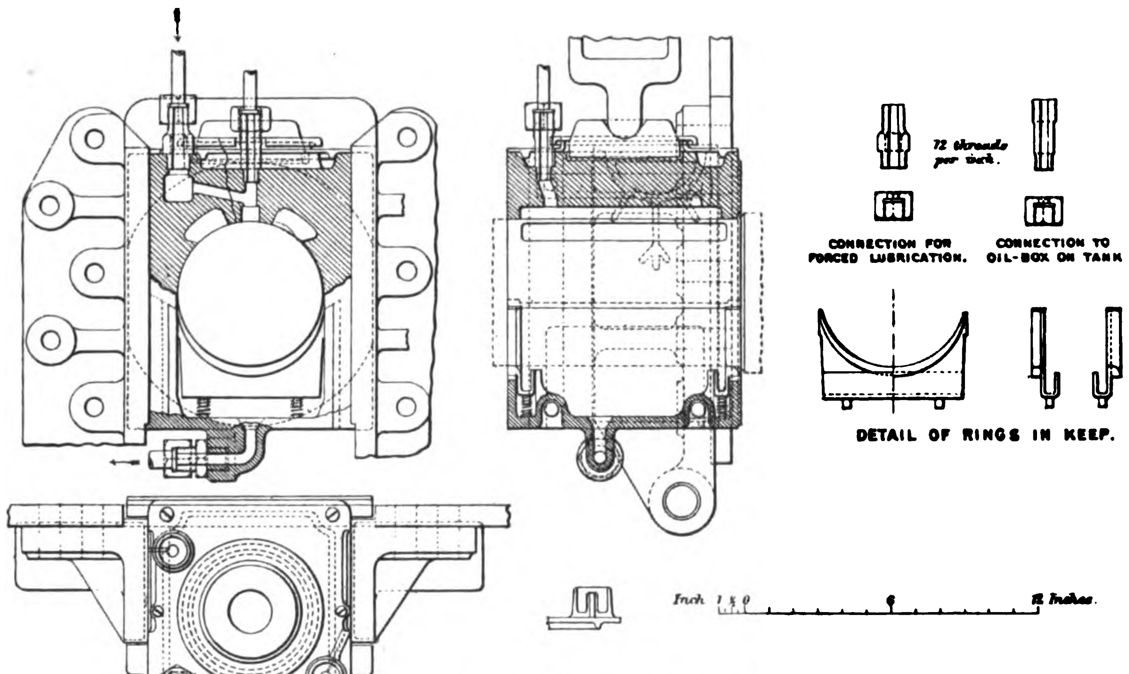


Fig. 3.—Driving Axle-Box and Keeps for Steam-Car on Taff Vale R.

the one for forward running and the other for backward running. These pumps are driven directly from the driving-axle by means of a belt passing over a flanged pulley carried midway between the pumps, the pulley containing on each side of it a roller-clutch, somewhat similar to a free-wheel arrangement, fixed to the driving-spindle of the pumps. By these means, the one belt drives either pump forward or backward, the other pump being free.

After passing round the journal, the return oil is collected in the axle-box keep, and from there is brought back to the tank by means of a flexible pipe which allows for the rise and fall of the axle-box, care being taken that the reservoir into which the oil is returned is sufficiently below the keep to drain it. At each side of the axle-box keep a half-ring is fitted with bearing area about $\frac{3}{8}$in. wide. These half-rings are bedded well to the axles, and are supported upon a couple of small coil

springs which hold the rings up to the journal with a fair pressure, and so prevent the escape of oil along the journal on the bottom side. The supply tank is so arranged that the return oil, after draining from the keep into it, shall pass through a filter before being again sent through the pump. Such briefly is a general description of the method adopted.

Many points arise however in regard to the working of the arrangement which it will be well to explain. In the first place, the pumps when running fast (at a speed of 30 miles per hour, the revolutions of the pump are 440 per minute) deal with a greater quantity of oil than can be accommodated in the circuit at a pressure of, say, 20 lbs. per sq. in., above which, in practice, it has not been found advisable to work. A relief valve is therefore fitted to each pump with an adjustable spring which enables the pressure at which each pump shall work to be regulated. The excess oil, when pumping, simply passes back into the tank again, through the relief valve against the pressure of the spring. A small pressure-gauge connected to each pump, and fixed in the driver's cab, shows the pressure of the oil pumped on both forward and backward running, whilst also acting as an indicator should failure of either pump occur at any time. Should this happen from any cause, the ordinary system of lubrication, by means of a lubricating-box in the cab, is at hand. This lubricating-box is also necessary, to enable oil to be put into the axle-boxes after the car has been standing for a day or two, and so avoid starting away with dry axle-boxes.

To prevent the oil from the running pump flowing into the other pump and causing it to run backwards, a small ball-valve is placed in the three-way piece leading from each pump to the circuit. The movement of the axle-boxes relatively to the tank and pumps was met in the first instance by trying different sorts of flexible piping, but finally, ordinary coiled copper piping was adopted, both on account of its comparative durability and of its accessibility at any time.

The belt drive for the pumps at once gives a simple method of driving and one which allows for a small relative motion of the axle and pulley. It is apt, however, to soon become saturated with oil and then slipping occurs. An occasional application of one of the various belting mixtures, however, greatly reduces this slipping. When equal relief-valve springs were put in, it was noticed that the pressure indicated for forward and backward running varied considerably, probably due to the difference in the slip of the belt in each case. The filters in the tank are removable, and are taken out and cleaned at the end of each day's work, the oil being first drawn off through the stop-plug, the thicker part of the oil, after straining, being then replaced by a small supply of fresh oil.

The foregoing description shows one method of dealing with an everyday problem in connection with the running of railway motor-cars, or any rolling stock in which the pressure on the bearings, combined with the rubbing velocity, is excessive. The matter is one of importance to all concerned in the design and care of such stock. This short Paper has been written in the hope that it may be useful to some investigators of this subject.

Insulated Steel Sleepers.

Steel sleepers were first tried on the Bessemer and Lake Erie RR. in 1900. They were of the inverted trough-shaped type, 5 in. wide by 3½ in. deep, and weighed 208 lbs. The packing of the sleepers with the ordinary tools was found to be difficult and unsatisfactory. Subsequently I beam steel sleepers, weighing 180 lbs., were tried, and 1,200 were laid in October, 1904. The result of the trial was that 68,521 were laid down in 1906, and 98,296 in 1907, and soon there will be no less than 252,558 of these steel sleepers in use on the Bessemer and Lake Erie RR.

On the Pittsburg and Lake Erie RR. 3,000 have been laid, and Mr. J. A. Atwood, the chief engineer, has been good enough to send us some particulars concerning them. They have been laid in the north-bound freight line near McKees Rocks. They are spaced 20 ins. apart centre to centre, and ballasted with rock ballast as shown in fig. 1.

Fig. 1.—Insulated Steel Sleepers.

They are made by the Carnegie Steel Co., and are 5½ ins. deep, 4½ ins. wide over the top flange, 8 ins. wide over the bottom flange, and 8 ft. 6 ins. long. At 6 ins. from each end the bottom flange is indented so as to form projections

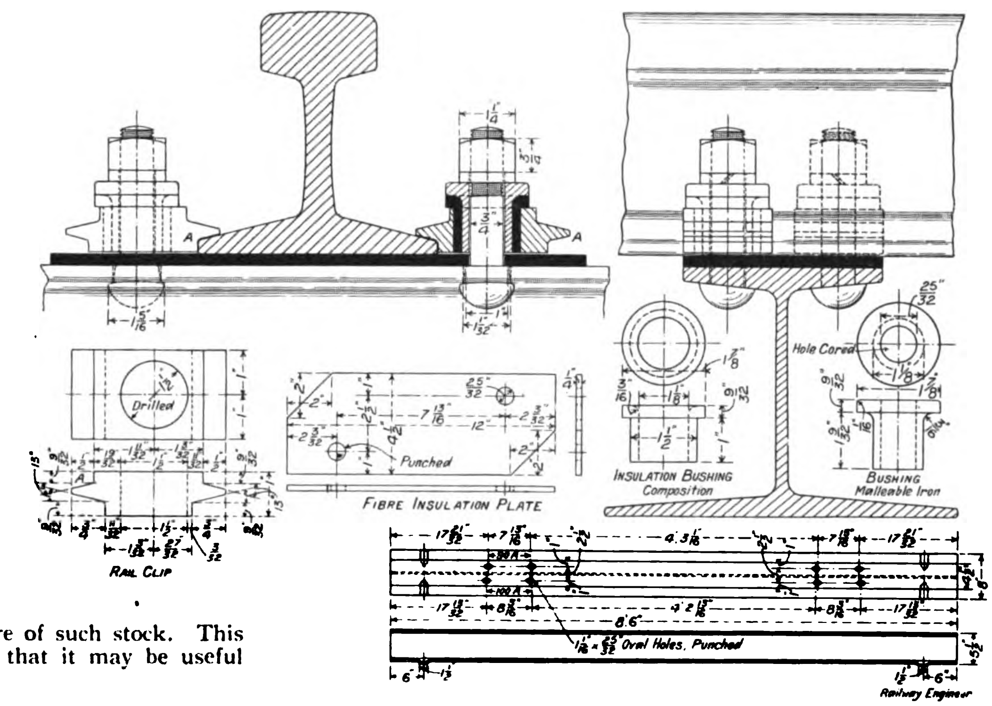


Fig. 2.—Insulated Steel Sleepers.

on the underside to resist lateral motion. Eight oval holes $1\frac{1}{16}$ in. by $\frac{25}{32}$ in. are punched through the top of the sleeper, four on each side, through which the fastening bolts are inserted. For the 100 lbs. Am.Soc.C.E. standard rail the holes are $8\frac{3}{16}$ ins. apart, and for 90 lbs. they are $7\frac{13}{16}$ ins. The fastening bolts are put through from the underside, the heads being made to fit the taper of the flange, as shown by fig. 2. The rails are secured by a clip having a hole 1½ in. diam.

Where track-circuits are employed for signalling purposes a composite insulation bushing, 1½ in. diam. outside, placed inside the clip, and within this a malleable iron bushing 1⅛ in. diam., through which passes the fastening bolt. A fibre insulation plate, 12 ins. by 4½ ins., is also placed

between the sleeper and rail, and also under the rail-clip, where track-circuit is employed.

The rail-clip not being symmetrical about the bolt hole will allow the rails to be fastened at 4 ft. 8½ in., 4 ft. 8¼ in., or 4 ft. 8 in. gauge. For the first-named gauge the clip must be placed so that the face **A** is on the inside of both rails.

Permanent Way.—IV.*

Ballast Wagons.

Ballast, be it stone or cinders, is conveyed on to the track in wagons holding about 6 tons and shovelled out into the six-foot whence at a convenient season it is placed into the track.

Some British, Colonial and American companies possess large hopper wagons for conveying ballast from the stone-breaker on to the road and there quickly unloading it.

The first to adopt this system in this country was the Great Western R., who found it of the greatest service in connection with the re-ballasting of their line when transverse sleepers were adopted in place of longitudinal baulks after the abolition of the broad gauge.

Fig. 20 illustrates the 20-ton ballast hopper wagons used on the Great Western R., and designed by Mr. G. J. Churchward, chief superintendent of the Locomotive Department. The principal dimensions are:—Wheelbase, 9ft. 6in.; length over the headstocks, 16ft.; size of hopper at top 15ft. by 7ft. 6in.; height above rail level 7ft. 10in. The point of the hopper is 5in. beyond the centre line so that the ballast is deposited centrally. The hopper door is 8ft. 8½in. by 1ft. 9in. It is hung by four hinges 2ft. 5¾in. centres and worked by two catch handles 3ft. 6in. apart and connected

Fig. 21.

by a piece of 1¼in. gas pipe and locked by "french" pins. The door has also a central looking bar secured by a "french" pin. The scantlings of the members of the framing are marked on the drawing, plating generally is 3/16in. thick. The hopper where it passes between the sole-bars is

*No. 1 appeared in the August issue; II. in September; and III. in October.

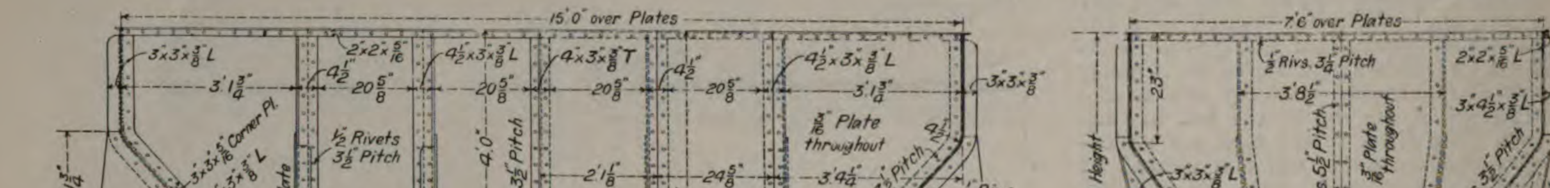


Fig. 20.

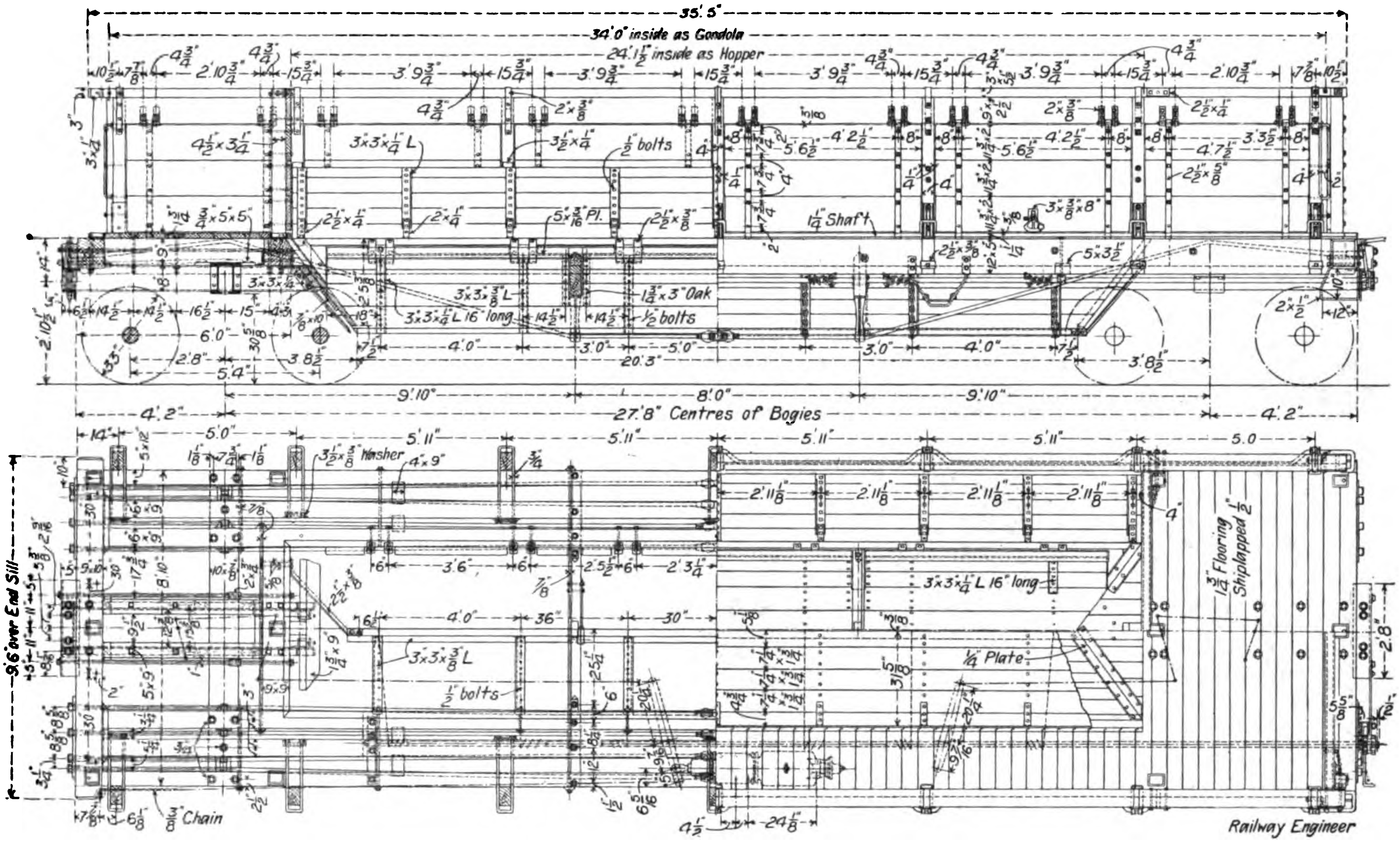


Fig. 22.

provided with a strong internal tie 2½in. diam. to resist the wedging strain set up by the load.

The Great Central R. use similar hopper wagons, but their door is moved by a ratchet wheel so as to be opened gradually and gently.

After the ballast has been deposited between the rails by the hopper wagon the train is drawn forward and (on railways adopting the system) the ballast is spread evenly by

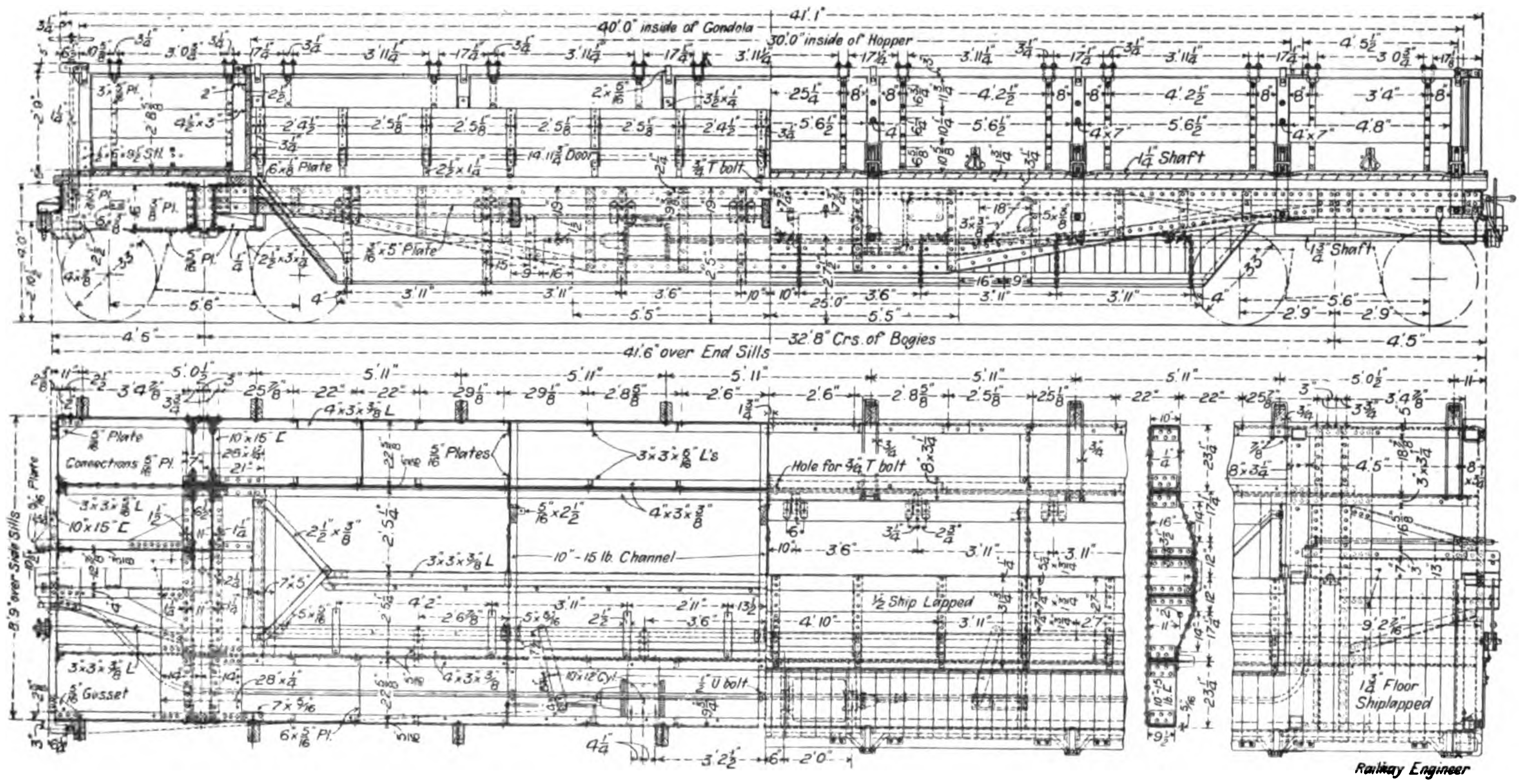
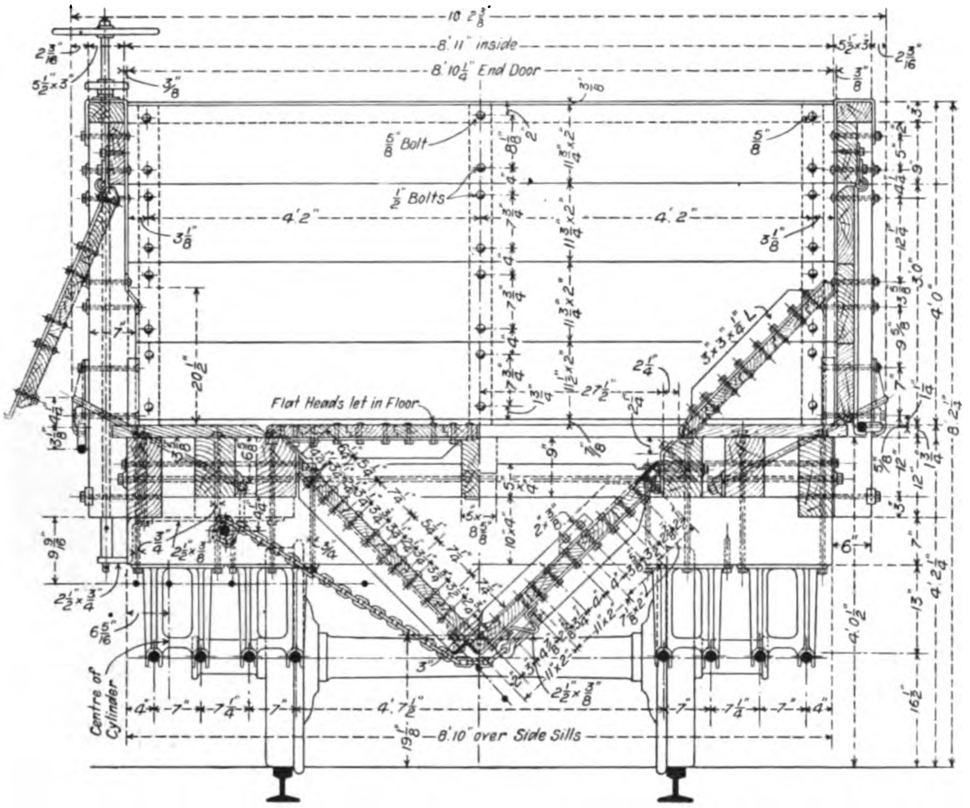


Fig. 24.



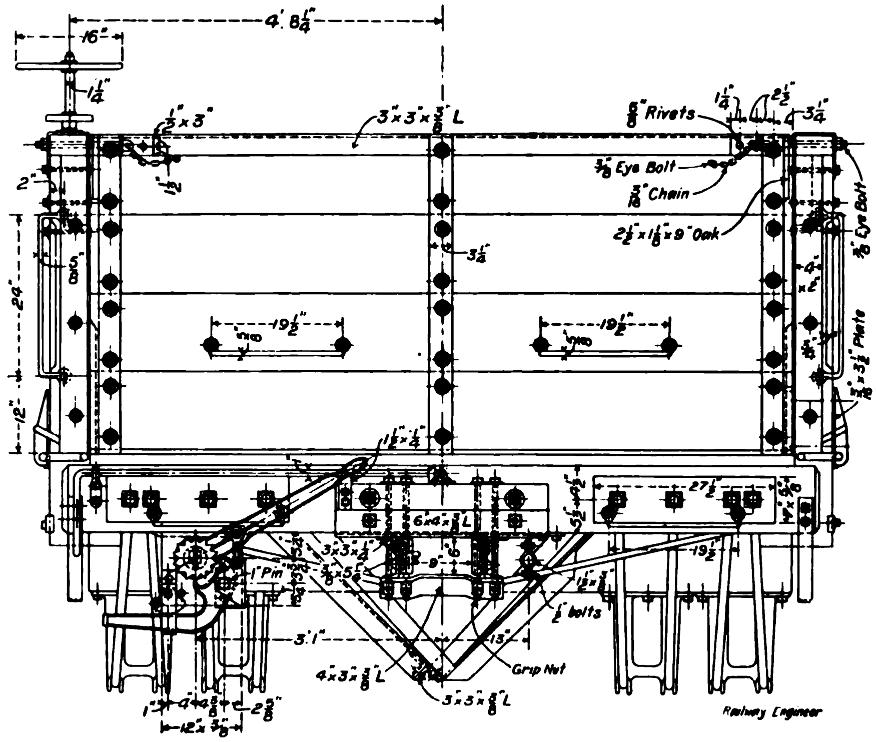


Fig. 23.

a plough attached to the van. Fig. 21 is a photograph of the ballast spreading vans on the Caledonian R.* There is a plough at each end which is raised or lowered by means of a hand wheel and screw forming the main gear. There are also two auxiliary screws to each plough—one on each side of the main screw—whereby the weight of the plough can be taken off the main gear. The spreading plates form an angle of 97° to each other. They are 8ft. 3in. broad and extend over the rails, for which they are recessed to clear, so that ballast is spread over the ends of the sleepers. When not in operation the spreader is raised by the hand-wheel and when fully up the bottom is 10in. above rail level. When in work the lowest part is 5in. below rail level.

Besides the Great Western and the Calendonian Rs. such ballast spreaders are used on the London and South Western, the Great Central, and Great North of Scotland Railways. The New South Wales Government R. have had the system in operation for some years, and in one of the Commissioners' annual reports it was stated that 72 cubic yards of ballast were unloaded and spread over 250 yards of railway in 5 minutes, employing only 2 men, whereas by the usual method 24 men would have been occupied 1¼ to 1½ hours in doing the same work.

In America larger cars are used for ballast purposes. One of these is the Hart Convertible Car made by the Rodger Ballast Car Co., of Chicago. These may be arranged to "side-dump" for construction work, "centre-dump" hopper for ballasting, or as gondola (low sides) cars for general service. They take a capacity of 40 tons and 50 tons. It is claimed that from $200 to $400 per mile may be saved by the use of these cars in depositing ballast in the middle of the line instead of the usual method of depositing it at the side and then shovelling it into the "four-foot." Thirty yards per minute can be placed on the line, and one run will provide 1,000 to 1,200 cubic yards of ballast per mile, or equal to a 5in. to 6in. rise. It is further claimed that it is cheaper to go over the same ground three times with this method than once by any other.

Figs. 22 and 23 illustrates the 40 tons wagon, and figs. 24 and 25 the 50 tons. The former is 36ft. long over the headstocks and 8ft. 11in. wide inside. When arranged as a "centre-dump" car it has a capacity of 30 yards, and when arranged for "side-dump" with a level floor of 44 yards. The 50 ton car is 41ft. 6ins. long and 8ft. 8ins. inside width. It has a capacity of 85 yards when arranged with a hopper and 88 yards when arranged for "side-dumping."

Another American car is the Goodwin,. which will "dump" or discharge from the side or middle or from both simultaneously.

Sleepers.

On this one subject alone enough might be said to fill a good-sized book, even if only timber sleepers were dealt with.

The woods mostly used are fir, pine, oak, beech, larch, eucalyptus, the hard wood of Australia, etc. Nearly all

*Sectional drawings and a full description of these vans appeared in *The Railway Engineer* for February, 1908.

British and Danish railways use Baltic red-wood, though a good deal of Australian hard wood has been laid in this country in recent years. Green oak is found on the French lines, green pine on the Russian, and oak on the American.

The British standard size for soft wood sleepers is 9ft. long by 10in. wide by 5in. thick. On the Continent the general sizes are 2*m.* 600 (8ft. 6·4in.) long by 180 *mm.* (7in.) by 120 *mm.* (4·72 in.), whilst American railways use sleepers (or "ties," as they are called in America) 8ft. or 9ft. long by 8in. or 9in. wide by 7in. deep. Sleepers made from timber that is only large enough to give one sleeper per cut are the best, as the heart is along the centre. Where a cut yields a piece of timber, termed a "billet," wide enough to make two sleepers the question arises as to whether the sleeper should be laid heart or sawn side upwards or downwards. The practice varies, as does the habit of having the top or sides of both rounded.

The stacking and seasoning of sleepers before they are treated for preservation, or, if not treated, then before they are put into the road, are very important matters for consideration, particularly from a financial point of view.

With the object of prolonging the life of sleepers they are usually subjected to some chemical or pickling process. Soft wood sleepers are usually creosoted. (A series of articles on "Wooden Sleepers" was published in the *Railway Engineer* for December, 1905, March, 1906, May 1906, July, 1906, and January, 1907, and in which the various processes were described at considerable length.)

The number of sleepers to each rail varies, first, according to the length of the rail, and, secondly, to local practice. In America they are closer together than in England. They have 2,816 sleepers in one mile of line, whilst we have 2,112 in a mile with rails 45 ft. in length.

In addition to wooden sleepers, there remains to be considered the use of steel sleepers and those, recently introduced, of ferro-concrete. Reference is made elsewhere in this issue (p. 367) to one pattern of steel sleepers.

Another question to be considered is whether sleepers should be covered by ballast. On the P.L.M. of France they are covered to a depth of 3 or 4 ins., and in warm and dry countries such may be beneficial, but the general opinion is that no harm can arise from the tops of the sleepers being bare, even when they have not been treated.

(*To be continued.*)

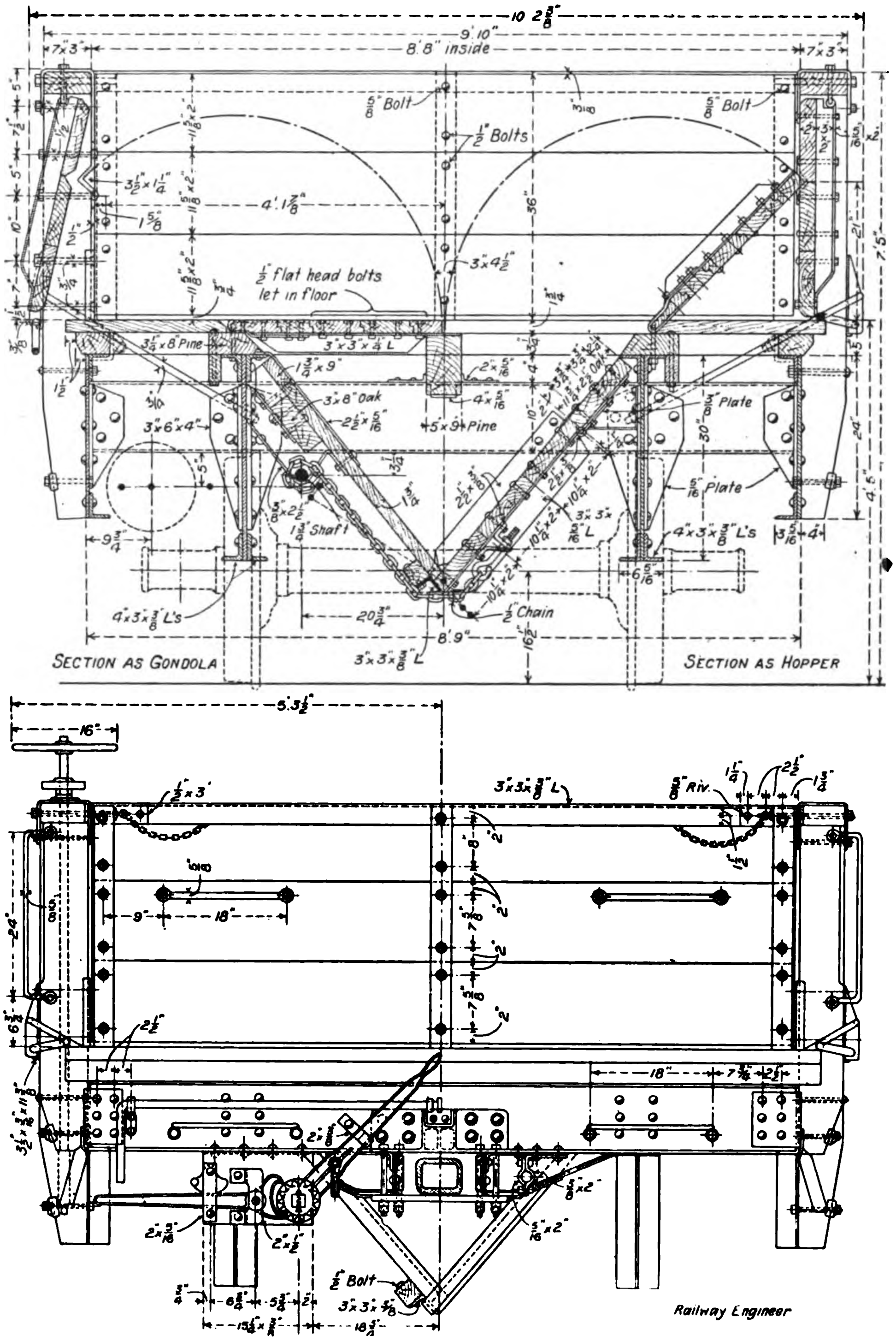


Fig. 25.

Electric Locos for Railway Trains.

The problem before the electric locomotive engineer is the transference of the power from the overhead conductor, or conductors, or from the insulated track conductor, to the axles of the driving wheels of the locomotives, in such a manner that the train is under complete control, from the driver's cab. And by complete control is meant the ability to provide the acceleration necessary to get up speed quickly on leaving a station, to vary the speed of the train as may be required, by the exigencies of the road, and to slow and stop the train quickly on emergency. It was explained in some articles which appeared in *The Railway Engineer** that for

*See Electric Motors for driving Machine Tools in April, 1906, June, 1906, and September, 1906.

workshop driving two forms of electric motor are available, viz., those working with continuous, or, as they are sometimes called, direct currents, and those working with two or three phase currents, and that the principal difference between these two forms of motors—two and three phase motors may be considered as variations of the same type—is in the fact that continuous current motors have commutators, and two and three phase motors have none. For railway work a third form of electric motor has been introduced, known as the single phase commutating motor. It was explained in the articles referred to that the single phase motor is of no use for workshop driving, and that it was on account of its shortcomings for work of the kind that two and three phase motors and two and three phase systems of distribution had been developed. It was explained that the single phase motor will not start against a load heavier than its normal, and that it will pull up if the load exceeds the normal. It was further explained that one of the peculiarities of alternating current motors is the fact that they are obliged to keep step with the generators which furnish the currents that drive them. Alternating currents, it will be remembered, rise and fall and reverse a certain number of times per second, and they do so in a certain regular order, each current rising and falling in a certain definite way. To accomplish this, the alternating current generators are constructed in a manner which provides for the rise and fall, and the number of alternations is accomplished by the number of magnetic poles, and the speed at which the machine runs. The motors which receive current from an alternating current service must take these currents exactly as they are generated, and use them exactly in the form in which they are delivered, and the successful operation of alternating current motors depends upon their properly accepting the successive alternations of the different currents, and properly employing them, by inducing other currents in the rotating portion of the apparatus. If the rotating portion of the apparatus cannot have the necessary currents induced in it, to enable it to set up the attractions and repulsions that give it motion, it gets out of step, and first loses its efficiency, and finally stops altogether. Two phase and three phase motors are now made to stand at least double their normal load without getting sufficiently out of step to lose the inductive action mentioned above. The ordinary single phase motor, however, has not yet, so far as the writer is aware, been able to accomplish this. But the form of single phase motor that has been developed for railway work is an apparatus quite distinct in itself. It is really a continuous current motor, with all the appliances, commutator, etc., that have been described in previous articles as being necessary parts of the continuous current motor, and it responds to, and will work with, continuous currents. In addition, however, to the continuous current accessories, arrangements are made for the motor to accept alternating currents. In the case of the single phase commutating motor two slip rings, as they are called, are fixed on the axle of the rotating portion of the motor, on the opposite side to that on which the commutator is fixed. It will be remembered that slip rings are the usual adjuncts of alternating current machinery. They perform one of the offices for the alternating current generator, or motor, that the commutator does for the continuous current generator or motor. It will be remembered that one office of the commutator of the continuous current motor is the delivery to the coils on the armature of the current from the distributing cables. The slip rings mentioned above perform the same office for the single phase commutating motor, in connection with the alternating currents. The two slip rings are connected to certain points in the armature coils, so arranged that the alternating currents passing to the slip rings, and thence from them to the armature coils, produce the attractions and repulsions between the magnetic fields created by the currents passing in the armature coils, and those in the stationary portion of the motor, that will set up rotary motion. Each slip ring is connected to two points 180° apart on the armature coils, the two sets of connections being therefore 90° apart, and the armature coils being divided into four parts by the four connections leading from them to the slip rings. The current is brought to the slip rings by brushes bearing upon them, the brushes being held by shoes, secured to any convenient stationary part of the machine, and the shoes or the spindles to which they are attached having terminal screws upon them, to which the ends of the supply cables are connected. The course of the alternating currents then, is from the supply cables to the slip rings, and thence to the armature, where they divide into two portions, embracing

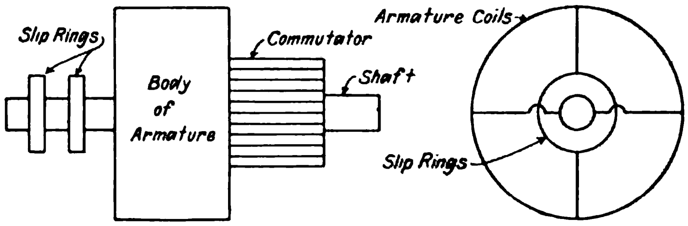


Fig. 1.—Showing diagrammatically the connections to a continuous current armature, to enable it to work with single phase alternate currents. The slip rings shown on the left of the longitudinal section, and in the centre of the transverse section all connected to points on the armature coils 90° apart.

between them the whole of the armature coils. Fig. 1 shows diagrammatically the arrangement of the connections for the armature coils to the alternating current service. The single phase commutating motor, it will be understood, responds to both continuous currents and single phase alternating currents, and it has been developed largely for those services which run between large towns, and in which high tension single phase alternating currents are employed outside of the towns, and comparatively low tension—500 or 600 volts continuous current—are employed in the towns. In practice, the motor may be considered as two distinct machines, according to whether it is furnished with a continuous current or single phase alternating currents. The change over from single phase to alternating is made by the driver on his arrival at the point where the supply service changes. The arrangement detailed above has been known for a long time, but it has only been brought to the front within recent years, owing to the demand for a flexible electric motor that would operate with only one supply conductor, either overhead or on the track. The motor as described is not complete. It does not sufficiently meet the requirements of a railway service, as described above, and additions, therefore, are made to it that will be described later on.

Another reason for the development of the single phase motor was the difficulty of constructing continuous current motors for high pressures. From the articles that have appeared in *The Railway Engineer* upon "The Distribution of Electric Current to Railways" it will be understood that the tendency of electric railway work is naturally to higher and

higher pressures. As explained in those articles, the higher the pressure at which the current can be transmitted, the smaller is the wire required to transmit it, the greater the distance over which power can be transmitted economically, and the more economical is the whole thing generally, where distance and power come in. As explained also, the early motors for trams and trains were worked at 500 volts, later motors working up to 600 and 650 volts, and it being arranged to utilise as much as 2,000 volts on a direct current railway service, by connecting motors together in series. But it will be quite evident that the limit in this direction is soon reached, and that the demand must arise for a motor that will work with higher pressures. One difficulty which has arisen, even with the comparatively low pressure of 600 and 650 volts, is the flashing at the brushes. As it has been explained, every change in the distribution of the current feeding any railway system gives rise to what are called inductive effects in every part of the system. Thus the sudden stoppage of several trains taking a large amount of current, or the sudden starting of several trains taking a large amount of current, give rise to inductive effects, which are felt by every motor on the line, and which lead to temporary flashing at the motors. In addition, when starting from rest, the powerful rush of current through the armature, tending, as it does, to overcome the magnetism of the stationary portion of the motor, also tends to cause serious flashing or blazing at the brushes. Designers of electric motors are able to overcome these difficulties by a special construction, and by the addition of what are called compensating windings. The special construction consists in laminating the iron of which the field magnets are constructed, so as to provide no closed secondary paths, and the compensating windings are arranged to neutralise the demagnetising effect of the powerful rush of current through the armature coils on starting. Continuous current motors can be constructed on these lines up to pressures of 1,500 volts, but for large railways 1,500 volts will not carry very far. As a matter of fact, on several of the electric railways at present in existence pressures of 6,600, and even 11,000 volts, are delivered to the overhead trolley wire. But the construction of the continuous current electric motor for 1,500 volts, with its laminated iron, and its compensating windings, is a construction that can be adapted to accept alternating currents, and to convert them into mechanical power satisfactorily. And this is really the construction of the single phase alternating current motor. It is a series wound continuous current motor, with laminated field magnet cores and compensating windings.

Another reason for the development of the single phase motor has been referred to in the articles on the distribution of current to electric railways, viz., the fact that with either two phase or three phase distribution the full pressure of the service must exist between two overhead conductors, while with single phase working the full pressure only exists between the overhead conductor and the return conductor.

Compensating Arrangements for Single Phase Commutating Motors.

The single phase commutating motor, as mentioned above, has taken various forms, according to the ideas of the particular inventors. The simplest arrangement is that employed by the General Electric Company of America and others, shown in fig. 2, in which an additional winding is added to the field magnet coils. The additional winding is intended to overcome the difficulties in connexion with an ordinary single phase motor and to provide accurate regulation, and in addition to overcome the difficulties of sparking when the speed of the motor is increased. In the articles upon "Electric Motors for Driving Workshop Tools" the methods of varying the speeds of electric motors were described, one of them being the reduction of the strength of the magnetic field of the motor when increased speed is required, the additional power being made up by additional current passing through the armature.

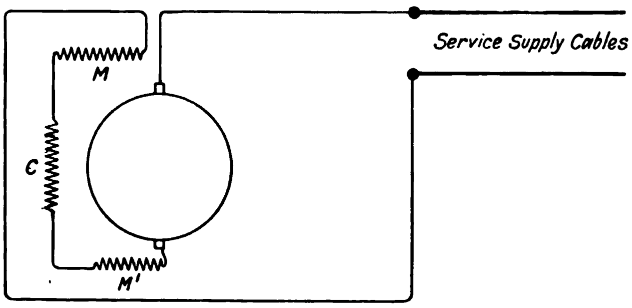


Fig. 2.—Showing one form of compensating winding for series wound continuous current motor, when working with single phase alternate currents. M[1] are the regular series coils, and C is the compensating coil.

With this method, however, when the magnetic field is weakened below a certain strength sparking at the commutator brushes takes place, and to meet this the commutating polar machine was introduced, the office of the additional poles being to neutralise the sparking by extinguishing the powerful current passing in each coil at the moment of commutation. The compensating windings in the simplest form of single phase commutator motors are practically arranged for the same purpose, and they are sometimes embedded in slots in the field magnet poles, and sometimes have other arrangements. The compensating winding is also added for the purpose of enabling the motor to furnish current to the distribution service when the train is going down hill. It has been explained that any continuous current generator is also a motor, and *vice versa*. If it is driven by mechanical power it will furnish current, and if it is furnished with current it will deliver mechanical power. Further, this reversal takes place automatically in the case of machines that are subject to reversals of power. Thus in the case of a motor driving a tramcar or a train, so long as it is furnished with current from the distribution service, it will work as a motor, and drive the car or the train, but if the car or the train is going down hill, and is furnishing mechanical energy to the motor, the latter will generate current, and should, with proper arrangements, deliver it to the distribution service. In the Central London Railway this property is made use of in the well-known arrangement by which, between each station, the train first descends for a certain distance, and then ascends. Further, the lifts, which are driven by electric motors, take current from the service when they are ascending, and deliver current to the service when they are descending. In street tramcar work it has not been possible to make use of the recuperative effect of motors upon tramcars going down hill, for various causes which cannot be entered into here; it may be mentioned, however, that methods are being developed which enable them to do so. For suburban traffic, in which trains

are required to start and stop very quickly, and in which a large power is required during the acceleration period, the recuperative effect mentioned is of importance, and this is obtained by the compensating winding described above.

(To be continued.)

Repairs, Renewals, Deterioration and Depreciation of Workshop Plant and Machinery.*

Most of the details of the management of an engineering establishment have, within recent years, been systematised. Systems now govern General Office, Drawing Office, and Works, from the filing of correspondence onwards; and no modern business can be economically carried on without them. They are the result of careful study of the requirements common to all engineering establishments, and the fact that they are *systems* points to a general consensus of opinion that what is good for one, is good—with modifications—for all, and that certain definite principles are applicable to all cases.

It therefore appears strange that the method of dealing with the wear and tear, repair and renewal, and depreciation of plant and machinery, has escaped attention, and that there seem to be as many different ways of treating this question as there are engineers, or, perhaps it should be said, as there are accountants.

Possibly a discussion of the subject by the Institution may tend towards some approach to uniformity of practice amongst the mechanical engineers having control of manufacturing works; and the author has therefore endeavoured in this Paper to bring forward the points which govern the question, and to make some suggestions for a system which shall provide for the proper upkeep of machinery, and for its replacement when no longer useful. This is a matter so vital that he hopes it may be found of sufficient interest for discussion, although the subject differs somewhat in character from those generally treated at these meetings.

The matter is very far from being, as many seem to believe, merely a matter of accountancy; in fact, the first reform would be to transfer the control of the machinery stock book, and everything connected with it, from the accountant to the engineer. While this Paper was in course of preparation, the subject of depreciation was treated in a leading article in an engineering journal, upon which comments were made by correspondents. This appears to indicate the recognition of the fact that the subject is an engineering one, and that our attention may with advantage be directed to it, while the correspondence also indicated diversity of opinion as to how it should be dealt with. The article in question, however, did not treat specially, as it is now proposed to do, with the plant and machinery of engineering workshops, which are not by any means under the same conditions as the rolling stock of a railway, or the generating plant of an electrical power station, if only because the *quality* of the product in the one case depends upon the condition of the plant, whereas it does not in the other.

It is beyond dispute that the efficiency of a manufacturing establishment depends upon the quality and condition of the plant and machinery therein, and that any neglect to maintain this equipment in the highest working condition promptly results in a falling off in both quality and quantity of output. The first question, therefore, to be considered is:—What is the best system to be adopted for maintaining the whole factory equipment in proper repair, and for discarding obsolete or worn-out machines, and replacing them with new machines when necessary? The second question is that upon which opinions differ so greatly, viz.:—How is the necessary financial provision for the maintenance and renewal to be made? Needless to say the two have to be considered together.

Maintenance.—The maintenance of the plant and machinery of a manufacturing establishment is generally one of the duties—and not the least important one—of the works manager, and much depends upon his judgment in deciding upon and executing the necessary repairs and renewals from time to time. It is, however, very unusual for this official to have any concern with, or knowledge of, the money value of the plant he is dealing with, and there would be an obvious advantage in the introduction of the reform previously indicated; placing the control of the repairs and renewals and of the valuation in the same hands, and limiting the accountant's duty in this connection to the use of the valuation provided for him by the engineer for the purpose of his profit and loss account and balance sheet.

The following system is suggested for adoption with the object of ensuring proper attention to upkeep of machinery and plant, which in a manufacturing establishment will consist of boilers, producers, furnaces, steam or gas-engines, electric generators, transmission (pipes, cables, shafting, etc.), possibly hydraulic and air-compressing and other machinery, together with cranes and similar gear, all only indirectly productive; with machine tools, steam-hammers and similar machines which are directly productive. The quality of the output is absolutely dependent on the quality and condition of the latter; the quantity and the cost, on the whole equipment. Besides the above, there are "loose tools," which are, in modern establishments, controlled by the "tool room" and may be left out of the present consideration.

Under the suggested system the control of everything would be vested in the works manager, or, in the case of large works, in a special official. The limit of his powers, as regards incurring expenditure, would be defined by the general manager, directors or partners according to circumstances; he would be responsible for the upkeep of the whole of the machinery and plant, and it would be his duty to report his requirements when he found them to exceed his financial limit; but it is essential that he should have considerable latitude in incurring expenditure on repairs, because obviously time is of the utmost importance in most cases, and he ought not to be bound by too much red tape; in machinery repairs "a stitch in time" often saves many times nine. There is no doubt whatever that if the right man be appointed there will be no difficulty on this point.

His first step must be to prepare a proper schedule of the plant and machinery in his charge, entering each item in the machinery stock book, with its distinguishing number. Against each item there should be entered its present value, calculated according to its age, in the manner to be explained later. Also a figure representing its *probable life* in years; this second figure will be required when provision for depreciation comes under consideration. (See Appendix I., showing the system of posting the machinery stock book for new works. The method of determining the depreciation *class* will be explained later.)

Probable life must always be a matter of opinion, but the development of mechanical engineering is now so rapid that it would certainly be unsafe to anticipate for the machinery of to-day the life of that of fifty years ago. For example, machine tools fifty years old may be very interesting and still capable of doing work, but their use is not conducive to commercial success, and it will not do to look forward to following the practice of previous generations in keeping old machinery at work.

The importance of properly estimating probable life will be apparent when depreciation is considered, and it is in this that the engineering skill and experience of the works manager or the special plant engineer will have their opportunity. The matter seems to have had no consideration whatever in the past; but a short time will suffice to produce plenty of men with the experience necessary to form a sound judgment on the probable life of any machine, that is, on the chances of its becoming obsolete by the arrival of new methods of working, and also of its wearing out in use.

The next step must be to make provision for proper care of the various machines, and for repairs being executed when required without delay. To ensure this, each attendant or workman in charge of a machine or group of machines, being the actual attendant or operator, and not a foreman, would be made, in the first instance, responsible for its being maintained in the highest possible condition, the fireman for his boilers, the turner for his lathe, and so on. It would be his duty to report immediately to his shop foreman any defect becoming apparent, and to enter on a card the description and number of machine, nature of defect, date, and his (the attendant's) name.

The foreman's duty would then be to inspect the machine, and, if in his opinion the repairs are necessary, to initial the card, and submit it to the works manager for final authority, the works manager initialling and dating the card and assigning a Works Order No. to the job. The repairs would then be executed at once, and on their completion the machine would be inspected and passed by the works manager, and their execution certified (with date) on the card; to which would be also added the cost incurred. This system would ensure proper care by the attendants of every machine, and would prevent ill-usage, which used to be one of the workshop troubles, though in this respect the modern workman is a great improvement on his predecessors, and the care of machines—especially machine tools—now leaves very little to be desired. It would also afford the works manager the opportunity of deciding when the time has come to replace instead of repairing—and it will be remembered that this official would have before him the "stock book" valuation of the machine under consideration, and therefore would know how far the cost of renewal had been provided for. He would see the whole situation at a

*A paper by J. E. Darbishire read before the Institution of Mechanical Engineers, October, 1908.

glance, and decide whether to replace, thoroughly repair, or partially repair.

In addition to the workman's or attendant's daily watching of each machine, periodical inspection should be made by the works manager as a check upon workman and foreman, and each such inspection recorded.

A suitable form for the card is given in Appendix III.

In the first space, the workman or attendant reports the defect noticed by him. In the second space, the foreman and the works manager record their inspection, and the latter his authority for the repair. The works manager, having assigned a Works Order No. for the repairs, can through that order authorise any further repairs necessary to the machine; there will generally be other defects to remedy, besides that originally reported by the attendant. In the third space, details are given of all the repairs when finished, this being signed by the foreman responsible for the repairs, who may, or may not, be the same as the foreman of the shop to which the machine belongs. In the fourth space, the works manager records his authority for the machine to be set to work again, and the foreman gives the date of re-starting. Finally, the cost is added in the fifth space, and the record is complete.

Depreciation.—It is sometimes argued that if machinery be maintained as indicated above, it does not depreciate, and that, so long as its output does not fall off in quality or quantity, it is as valuable to its owner when ten or twenty years old as when new. This, however, is absolutely incorrect, for although a machine could of course be kept "alive" for ever, by renewing its parts one by one as they wear out, supposing that it never grew obsolete, its value at any given time would depend upon the state of deterioration of its various parts at that time, because since each part has a "life," the effluxion of life of that part is proceeding from day to day. But machines do grow obsolete, and are not renewed in this way; and the depreciation now to be considered provides for that effluxion of life of each machine as a whole which actually takes place, the amount depending upon the time which a machine can be profitably used for the purpose of producing the output required by the works in which it is installed—this being its "life."

It is therefore absolutely necessary to make provision for a fund by means of which the various items of a workshop equipment can be renewed from time to time—which provision obviously has to be made without any reference to the profits or losses of trade. It must be made as part of the working expenses of the business, and in this respect the author protests against the system frequently adopted by accountants of showing a so-called "profit" out of which so much is set aside for depreciation, the amount apparently being at the discretion of the directors or the accountants, and frequently depending upon the amount of the so-called "profit." It is clearly wrong to make the provision for depreciation a charge on profits, for depreciation is really a loss of the capital assets, which has to be made good out of income, and is just as much a charge on revenue as rent or taxes; there is no escape from its incidence, and there is no profit until adequate provision for depreciation has been made. That the provision should be adequate goes without saying; the amount must be determined without reference to the result of trading, but must be an absolute charge, so that the depreciation may be truly representative of the loss of value of the machinery, which occurs whether trading is profitable or not.

When therefore a machine is new, the probable life having been estimated, the depreciation on that machine can be determined, the sum of the loss during life being the new value less the scrap, or ultimate value. This has to be written off during the life in gradually decreasing increments by fixing a percentage to write off each year from the last year's value, this percentage being such that at the end of the life the depreciated value shall equal the scrap value.

It must be noted that the ultimate values of machines expressed in percentages of their new value vary considerably, because an expensive special light tool will probably have a lower scrap value than a much less expensive heavy tool, such as an ordinary planing machine or a heavy lathe.

It is clearly impossible to foresee either probable life or ultimate value with absolute accuracy, and it would be a refinement of detail to treat each machine on a basis of its own, even if it were possible; but having estimated the probable life and ultimate value individually, each machine may, for depreciation purposes, be assigned to one or other of the classes indicated by the curves on fig. 1, the class selected being that giving the nearest resultant scrap value at the end of the probable life.

Such a provision as the above is sufficient to cover loss due to deterioration beyond that made good by repairs; because in estimating probable life, the chance that a machine may wear out before it becomes obsolete is taken into consideration.

It must, however, be borne in mind that special conditions apply, in the case of leasehold premises, to certain machinery which passes with the hereditament; and when the period of lease is shorter than the probable life of any such machinery, it becomes necessary to apply a rate of depreciation which will *entirely* extinguish the valuation at the expiry of the lease, not even scrap value remaining. In such a case, it is simplest to write off an equal instalment each year, dividing the present value by the number of unexpired years of the lease.

The amount of depreciation on each item being determined, the total on the whole plant must be charged against the income of every year, if the balance-sheet is to show truly the value of the plant, and consequently the actual profit or loss of trading.

The author believes that it is essential to schedule every item, and to write off the depreciation separately, so that the Stock Book may show the actual present value of every machine. It may prove, in the course of a machine's career, that for some unexpected reason it is found that its life is likely to fall short of, or to exceed, the estimate to some considerable extent. In such a case there is no reason why it should not be considered on its merits, and the rate of depreciation increased or reduced from the time when its unexpected weakness or vitality became apparent. This would provide against the absurdity of a useful machine standing in the Stock Book at scrap value—but any changes in depreciation should only be made with authority; accurate judgment in estimating probable life will prevent such cases occurring.

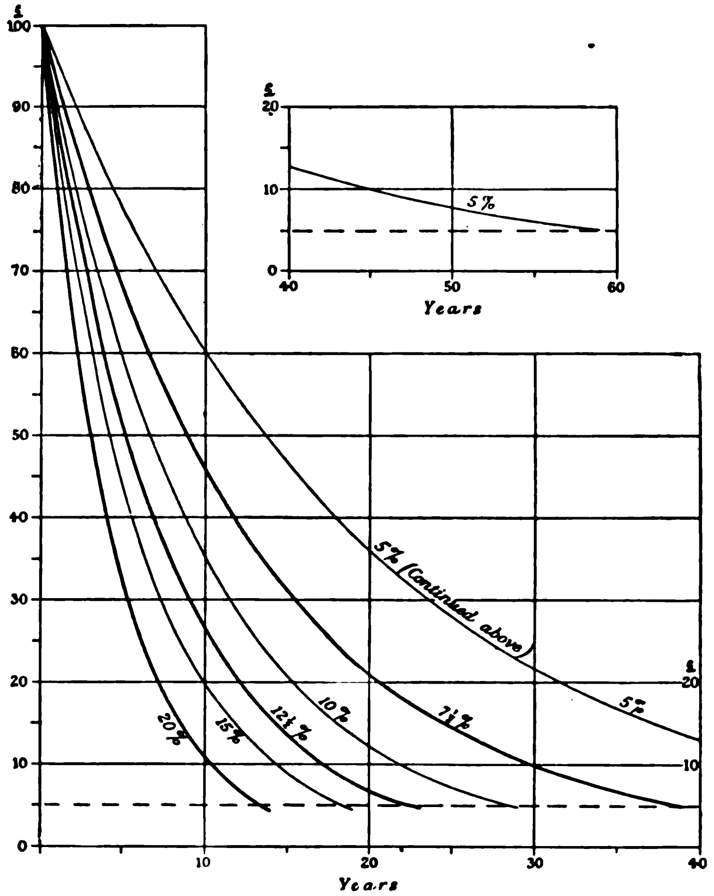


Fig. 1.

When a machine is replaced it disappears from the Stock Book, and its successor takes its place at its new value, being paid for out of the accumulated funds. Thus the valuation would be unchanged in the event of new machines replacing old ones to the exact extent of the total sum set aside for depreciation in any year.

There is still a provision to be made for the cost of repairs, which is usually met out of income, as it is incurred each year. This is perfectly sound in works which have been established for some time, but in the case of new works equipped with entirely new plant—as the repairs for the first year will be practically nil, and for the next few years very slight, whereas they will fall heavily on some later years—it is wise to set aside a sum during each of the early years to provide for this. After a few years, the requirements for repairs equalise themselves, owing to the varying rates at which the different items require expenditure.

Increase in the productive power of works due to the installation of additional machinery warrants a charge upon capital, and such

APPENDIX I.

The.................................Engineering Co., Ltd.

MACHINERY STOCK BOOK.

Date: *31st December*, 1897.

No. of Machine	Description.	Depreciation. Class.	Present Value.
	Machine Shop A.		
1	18-inch Sliding, Surfacing and Screw-cutting Gap Lathe, with 24-foot Bed, Driving Apparatus, etc., complete. (By A. B. & Co. New; probable life 30 years) . .	2 (7 %)	£ 400
2	4 feet 6 inches square by 15 feet long Planing Machine, 2 Tool-boxes on Cross Slide, Driving Apparatus, etc., complete. (By C. D. & Co. New; probable life 30 years)	2 (7½%)	500
3	Special horizontal Milling Machine for light work, Vice, Set of Mandrills and Driving Apparatus, etc., complete. (By E. F. & Co. New; probable life 20 years) . .	5 (15%)	100
4	10-inch Stroke Slotting Machine, with Driving Apparatus, etc., complete. (By G. H. & Co., second-hand from X Y & Co.'s Sale. Was new (£100) in 1885; probable life 25 years)	3 (10%)	28

APPENDIX II.

The.............................Engineering Co., Ltd.

MACHINERY STOCK BOOK.

Date: *31st December*, 1907.

No. of Machine	Description.	Depreciation Class.	Present Value.
	Machine Shop A.		
1	18-inch Sliding, Surfacing and Screw-cutting Gap Lathe, with 24-foot Bed, Driving Apparatus, etc., complete. (By A. B. & Co. New in 1897)	2 (7½%)	£ 184
2	4 feet 6 inches square by 15 feet long Planing Machine, 2 Tool-boxes on Cross Slide, Driving Apparatus, etc., complete. (By C. D. & Co. New in 1897) . . .	2 (7½%)	230
	Two Tool-boxes on Uprights added in 1905, then cost £50	4 (12½%)	38
3	Special horizontal Milling Machine for light work, Vice, Set of Mandrills and Driving Apparatus, etc., complete. (By E. F. & Co. New in 1897)	5 (15%)	20
4	10-inch Stroke Slotting Machine, with Driving Apparatus, etc., complete. (By G. H. & Co. New in 1885)	3 (10%)	10

APPENDIX III.

The................................Engineering Co., Ltd.

REPORT ON DEFECTIVE MACHINE.

Department..

Machine No. .... *Description*..

Defect noticed

Attendant's name........................... *No*.......... *Date*..........................

Repair recommended..Foreman.
Date..............

Approved.. Works Manager.
Date..............

Works Order No..Date..............

Report of Repairs completed. Date..............
Particulars.

....
Foreman responsible for Repairs.

Passed for Work.. Works Manager.
Date..............

Re-started... Foreman.
Date.............

Cost of Repairs.

Remarks.

machines appear in the Stock Book as additions to plant, although no additional capital may have been raised to pay for them.

If additions to individual machines increase their productive capacity, the cost of such additions may fairly be added to their Stock Book value, but they must then be depreciated at such a rate that the additions are written off by the end of the life of the machine.

Appendix II. may now be compared with I. It shows the same plant ten years later, the items having been dealt with in the manner previously indicated. It will be noticed that the planing machine has had an addition to its productive capacity; also that the slotting machine, which was second-hand when the works started ten years before, is now at a figure which permits of its replacement by a more modern machine.

The results of unsound finance in dealing with depreciation are so serious that it may surely be said that every establishment ought to be put on a sound basis, the actual present value of the machinery and plant determined, and systematic provision made for depreciation, so that when renewals become necessary, their cost is provided for. It is often stated that when a business is working at a loss, there can be no provision for depreciation, which in a sense is true; but depreciation is going on all the same, and the accounts ought to show the loss fairly and squarely—that is, the depreciation sum should be written off, whatever the results of trade. If a recovery takes place, the position is sound; if not, continued losses mean the end of the business, and the valuation of the plant at its right figure will not affect this.

The danger of under-provision for depreciation, and especially of allowing the amount to depend upon the results of any year's trading, is that in lean years what ought to be set aside for depreciation may be entirely or partially distributed in dividends, which is nothing more or less than paying dividends out of capital. This may be done in the expectation of better times to come, when the depreciation deficiency may be made up; but it is quite unsound, and in many cases has brought about the results which might have been expected. Even now, there are too many works equipped with machinery which is so out of date as to be a serious handicap in manufacturing, but which cannot be thrown away and replaced because past years have not provided the means to meet the expense. To raise fresh capital for this purpose, even if feasible, is absolutely unsound finance, for the new machinery has to produce sufficient to provide interest on the lost capital as well as on the new.

In fact, over-valued machinery is one of the most dangerous enemies to financial safety; it would be far better to distribute less and set aside more for depreciation, than to live in a "fool's paradise," and awake to find that the time has come when machinery must be modernised to meet competition, and that the funds to do this are non-existent.

As a matter of accountancy, in order that the balance-sheet may show the true value of the plant, this should be entered at its depreciated value; the depreciation should not be treated as a separate or "Reserve" fund, though if this separate fund be sufficient, the financial position is quite sound. The essential thing is that it should be sufficient, and that it should be provided for before the word "profit" is as much as thought of. This means that the statement or valuation must show the real value of the plant and machinery. However fascinating mechanical engineering may be, the aim of all manufacturers is to work at a profit, and no true profit is shown if the valuation of the plant is incorrect.

Depreciation as a charge against revenue is admitted in principle by the Income Tax authorities, and in rating valuations the rateable machinery and plant are assessed at their depreciated value. This, however, is a somewhat thorny question, and although the author feels that it should not pass unmentioned, it is perhaps hardly one for consideration in connection with the present subject, which is that of workshop practice as affecting the effective maintenance and the true valuation of machinery and plant.

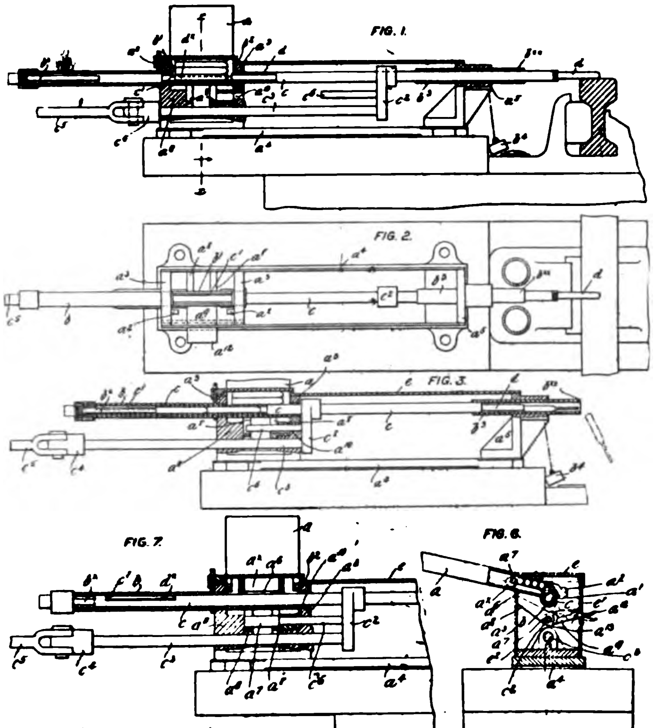
Recent Patents Relating to Railways.

THESE abridgments of recently published specifications are specially compiled for this review by Messrs. Wheatley and Mackenzie, Chartered Patent Agents, 40, Chancery Lane, W.C., from whom copies of specifications can be obtained at an uniform price of 8*d*. each.

Fog Signalling Apparatus. *7,913. 9th April, 1908. J. Parker, 27, Agnew Road, Honor Oak Park, London, S.E.*

This invention is an improvement connected with a Prior Patent No. 18584[05], which relates to apparatus for use with detonators of the pencil type. The carrier *c* has its cut-away portion c^1 located at its rear end, to take the cartridge or detonator at the

end of the outward stroke, instead of as in the prior patent at its front end, so that the carrier whilst working to and fro in the tube b is always under cover, the detonators carried by the carrier being ejected in the manner set forth in the prior patent. To effect the reciprocating movement of the carrier the same is connected by an arm c^2 with a rod c^3 passing through the standards a^3 and terminating in an eye or the like c^4, to which is connected the rod or the like c^5 operable by the fogman or from the signal box. On the detonator d being exploded the carrier c is drawn back so that the last detonator d^* fed therein engages with the end of the ejector rod b^* in the tube b^*, the carrier c continuing its movement till arm c^2 butts against the standard a^3, such rearward movement expressing the spent detonator. In order that an indication of

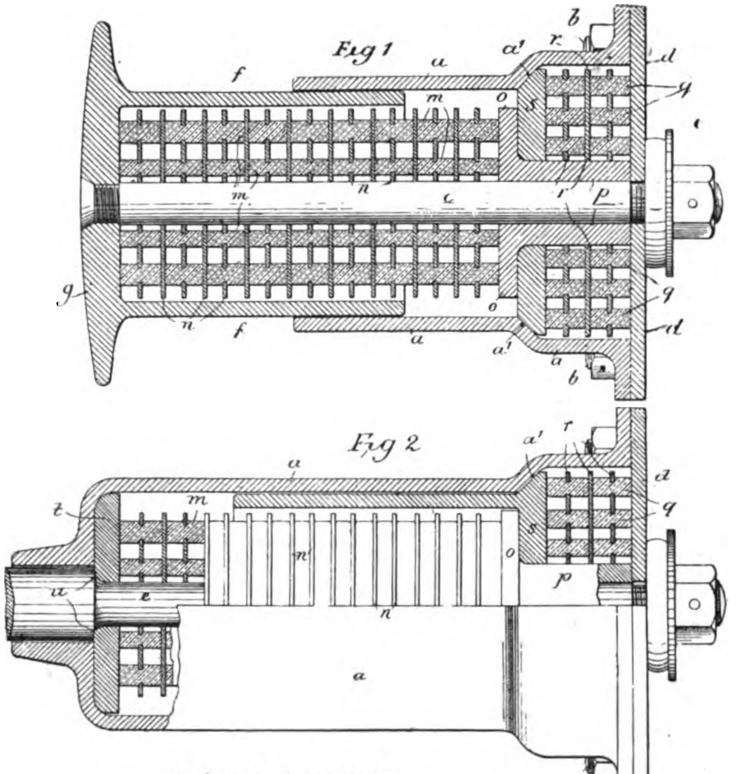


Railway Engineer 7943/08

the state of the magazine may be given, the bottom plate a^* of the magazine a is cut away at a^6 so that the roller or follower a^7 drops through on the requisite detonators being used, the roller a^7 falling on to the inclined guides a^8, rolling down same till stopped by the intercepting pivot pawl a^9, the roller a^7 covering the hole a^{10} in the rear standard and resting so that the rod c^6, carried by the arm c^2, which in the ordinary working passes through the hole a^{10} butts against the end of the roller a^7, pressing the same against the boss a^{11}, thereby preventing any further backward movement of the carrier and its attendant parts. To release the roller a^7 the intercepting pawl a^9 is raised by depressing its end a^{12}, so that the roller may pass underneath the pawl, as shown in dot and dash lines, and out through the opening a^{13} in the side plate c^1, allowing the carrier and its rod c^5 to continue their movement. (*Accepted 18th June, 1908.*)

Buffers. *415. 7th January, 1908. A. Spencer, 77, Cannon Street, London.*

This invention relates to buffers in which two springs or sets of springs are provided, one to effect the initial buffing and the other to effect the remaining and most severe portion of the buffing. The main buffer spring is constructed of sets of concentric indiarubber rings m with separating rings n, and is threaded on the rod e between the buffer head g and the flange o of an abutment collar p that slides on the rod e and the inner end of which bears against the metal plate d. The supplementary buffer spring is constructed of sets of concentric indiarubber rings q with separating rings r like the main spring m, n, but a fewer number of sets of concentric rings and separating rings are used. It is arranged between the closing plate d of the case or guide and a metal ring s which is threaded on the collar p between the supplementary spring and the flange o of the collar, and has an inclined marginal outer face which normally bears upon a correspondingly inclined support or shoulder a^1 formed in the buffer case or guide which is enlarged to receive the said ring and supplementary spring. The latter spring is or may, as shown, be of greater diameter than the main spring. The arrangement is such that when buffing the buffer rod is forced

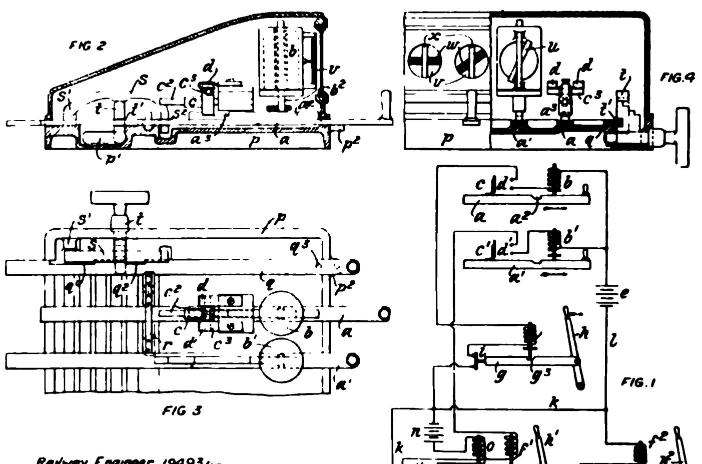


Railway Engineer 415/08

inwardly and the initial buffing effected by the main buffer spring m, n, after which continued inward movement of the buffer rod will cause the inner end of the sleeve f to abut against the ring s so that the remaining and most severe portion of the buffing action will be effected mainly by the supplementary spring $q—r$, the full compression stroke of the combined springs being such as to prevent shock due to contact between the buffer head g and the case or guide a. Fig. 2 is a similar view to fig. 1, illustrating an arrangement in which the main spring m, n is located between the flange o of the collar p and a metal ring t that abuts against a shoulder u on the buffer rod e. In this construction the sleeve f is formed in one with the metal ring s of the supplementary spring $q—r$, although it may in some cases be formed in one with or connected to the metal ring t, or consist of a loose sleeve located between the two rings, or between the ring s and the buffer head in an arrangement such as shown in fig. 1. (*Accepted 23rd July, 1908.*)

Interlocking. *19,493. 30th August, 1907. Siemens Bros. and Co., Ltd., 12, Queen Anne's Gate, Westminster, and L. D. M. G. Ferreira, 102, Elmbourne Road, Upper Tooting, Surrey.*

This invention relates to interlocking arrangements for signal and point levers which are controlled from a central station. At the



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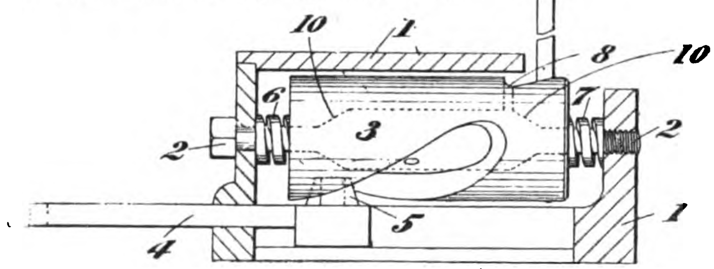
central station, such as the stationmaster's cabin, there is a number of tappets a a^1 each controlled by an electro-magnetic lock b b^1, and carrying a switch arm c c^1 adapted to complete a circuit at contacts d d^1 when the tappet is drawn in the direction of the arrow. Assuming that tappet a is operated, this circuit is from battery e through magnet b, switch c, magnet f of the lock controlling the tappet g of the signal lever h, which, for instance, operates the home signal for up-trains entering the station, switch i on this tappet g and lines k and l back to battery e. Magnets b and f are now energised, with the results (1) that the locking bolt of the former is prevented from falling into notch a^2 on tappet a, should the stationmaster find it necessary immediately to rescind his decision and to move the tappet back to its normal position, and (2) that the locking bolt of magnet f is lifted from notch g^3 on tappet g and the signalman can pull the lever h in the direction of the arrow to put the signal to line clear. This movement breaks the circuit at switch i and magnets b and f are de-energised, the bolt of the former falling into notch a^2 and thus locking the tappet a, while the bolt of the magnet f rests upon tappet g. When the signalman returns lever h to put the signal to danger position both magnets are again energised and the stationmaster can return tappet a to its normal position, thereby again de-energising the magnets and locking the signal lever. In some cases it is desirable to control levers in a second cabin from both the stationmaster's cabin and the first cabin in the following manner:—The tappet a^1 controls the lever h^1 in No. 1 cabin which in its turn controls the lever h^2 in No. 2 cabin. When a^1 is moved in the direction of the arrow and switch c^1 is closed, the circuit is from battery e through magnet b^1, magnet f^1, switch i^1, and lines k l back to the battery. The locking bolt of magnet b^1 is now held up and that of magnet f^1 is lifted from notch g^4 in tappet g^1, so that lever h can be pulled. As soon as it has been pulled, the circuit including magnet b^1 f^1 is broken and tappet a^1 is locked. When lever h^1 is fully reversed, switch i^1 closes a circuit at contacts m from battery n, through magnet o, switch i^1, contact m, switch i^2, magnet f^2 and line k back to the battery n. The bolt of magnet o is thus held up, so that the lever can be immediately returned if required and the bolt of magnet f^2 is lifted from notch g^6 of tappet g^2 to unlock lever h^2 which can thereupon be moved to lower the signal to the "line clear" position. This movement breaks the circuit at switch i^2 and the bolt of magnet o falls into notch g^5 of tappet g^1 to back lock the lever h^1 until lever h^2 has been returned to normal position. There may be any reasonable number of tappets a a^1 controlling as many different signal and points levers, and these may be mechanically interlocked in any known manner, so that a^1 cannot be moved unless a is in normal position and *vice versa*. The apparatus shown in figs. 2 to 4 is intended for use with the interlocking arrangement, and includes a locking device for an Annett's key which is frequently used for locking siding points or the like in working a single track. (*Accepted* 30*th July*, 1908.)

Switch Mechanism. *1,297. 20th January, 1908. H. A. Thomson, Dunalastair, Cragie, Perth.*

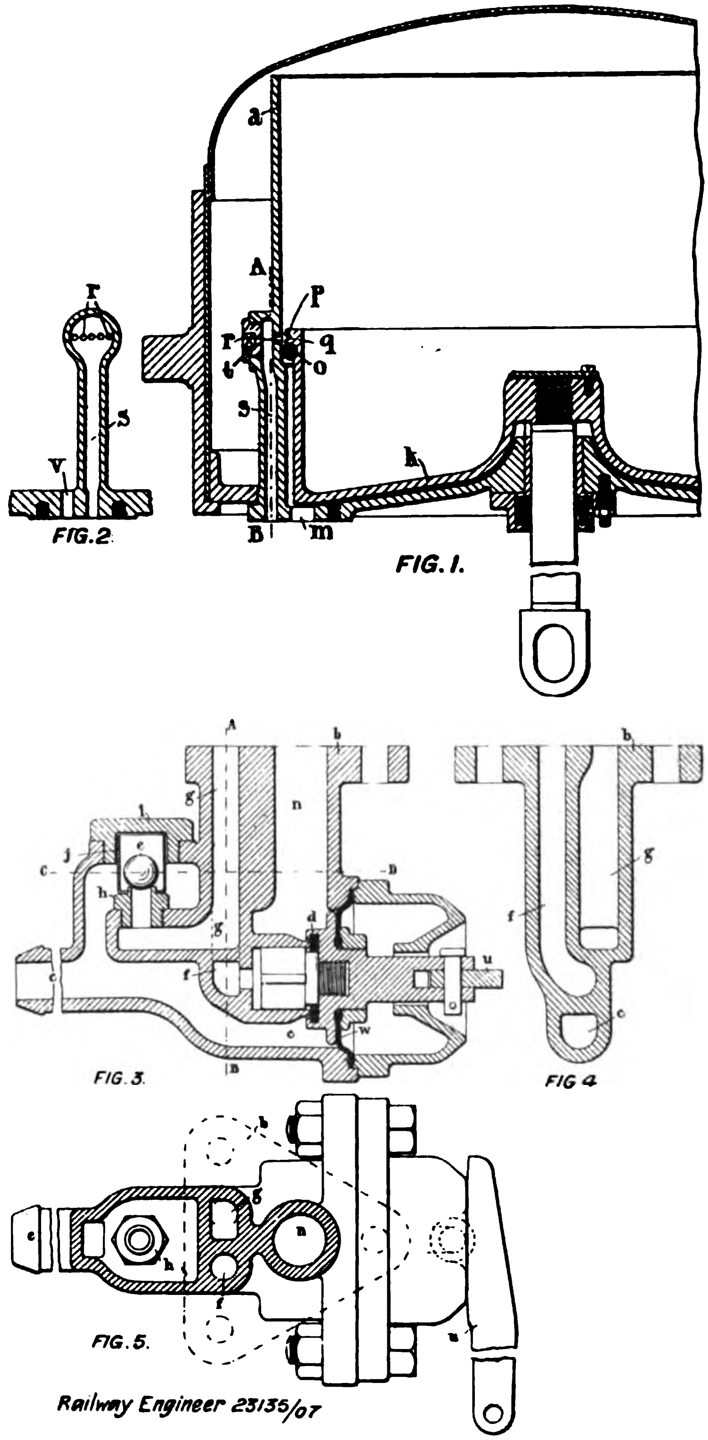
The cam 3 engages through the medium of a conical roller 5 with a pull and push bar 4 which is fitted to slide in a groove formed in the casing 1. One end of the bar 4 is attached to the pull rod of the points. Two springs 6, 7 are inserted one at each end of the worm. On operating the lever handle 9 to produce sliding motion of the bar 4, the springs 6 and 7 absorb the end thrust and tend to prevent breakage of the mechanism. When motion is given to the lever handle 9 by a train passing trailing ways through the points the springs 6 and 7 act as cushions and absorb the impact of the weight 11. The lubricating of the springs 6 and 7 is performed in the usual manner by pouring a small quantity of oil through the hole 8 into the cylinder core. The circular motion of the cylinder laps the oil up its sloped ends 10 on and along the spindle 2 to the springs 6 and 7. (*Accepted* 9*th July*, 1908.)



Railway Engineer 1297/08

Vacuum Brake Apparatus. *23,135. 19th Oct., 1907. H. E. Gresham and G. Kiernan, Craven Iron Works, Salford, Lancaster.*

This invention is intended to prevent leakage of air, when the brakes are in operation, into the vacuum in the brake cylinders on the upper side of the pistons working in the cylinders. To the lower end of the brake cylinder a is connected the valve casing b which is adapted to communicate with the train pipe c and with the upper and lower ends of the cylinder a. The valve



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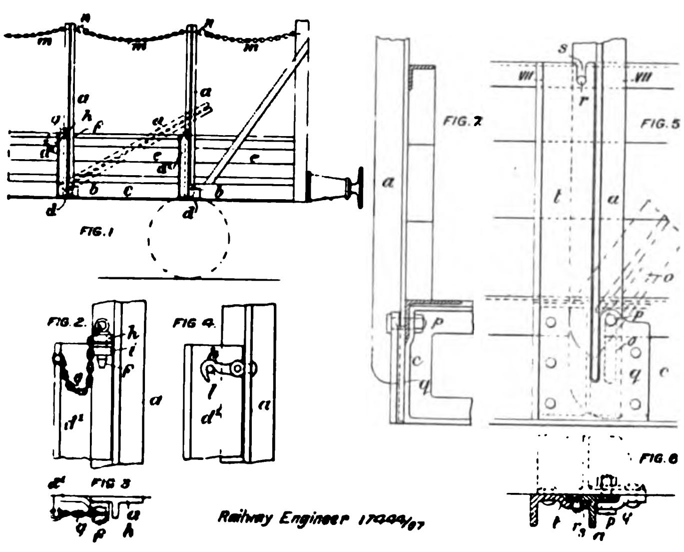
casing is fitted with a diaphragm or other valve as d and a ball valve e, each of the valves controlling a pipe or conduit f and g respectively forming parts of communicating passages between the interior of the valve casing and the upper end of the brake cylinder. A seating is provided for the ball valve e in the casing itself, and independently of the diaphragm or equivalent valve. By preference the seating comprises a nipple like part h adapted

to be screwed in position through an insertion and inspection aperture in the casing, the aperture being closed by a screw plug *i*. To prevent loss or derangement of the ball valve *e* on the opening of the closure piece *i*, a gauze like or other cage *j* is provided for containing the ball, a positioning or retaining recess being formed in the underside of the closure piece *i* for the reception of one end of the cage. The ball valve *e* serves as a non-return valve for the upper end of the brake cylinder *a* only when the brakes are inoperative or in the "off" position. The piston *k* within the brake cylinder *a* is of the usual trunk type now employed. Around the flange is cut an annular groove *q*, and in alignment therewith when the piston is in its inoperative position shown a lateral aperture or group of apertures *r* are formed in the brake cylinder, and communicate by a vertical air way or passage *s* with the conduit *g* in the valve casing. When air is admitted to the underside of the piston *k* in the usual manner for the operation of the brakes, the movement of the piston will carry its packing ring *o* above the lateral apertures *r*, and will thus, by allowing air to flow from the underside of the piston to the external conduit *s* with which such apertures *r* communicate, put both sides of the ball valve *e* under the influence of the atmosphere within the pipe *c*, and so render the said valve *e* inoperative. But the fact of the packing ring *o* being above the lateral apertures *r* will also cut off communication between the upper end of the cylinder *a* and the lateral apertures *r* opening into the external air conduit *s*, and thus leakage of air into the vacuum above the piston *k* will be prevented and the brakes maintained in the "on" or operative position. To permit of ready access to the vertical air conduit *s* and the lateral apertures *r* aforesaid, a detachable plug or cap *t* is fitted at the upper end of the conduit *s*, and so that on removal of the plug both the conduit and the lateral apertures *r* are exposed to view. For releasing the brakes after an application of the same, in the ordinary manner, the vacuum is restored at the lower side of the brake cylinder *a*. But when it is desired to release the brakes of a coach or carriage detached from an engine the diaphragm valve *d* is moved from its seat by means of the arm *u* to allow of communication between the pipe *c* and the top of the brake cylinder through the pipe or conduit *f* and aperture *v* which the diaphragm valve controls. (*Accepted 2nd July, 1908.*)

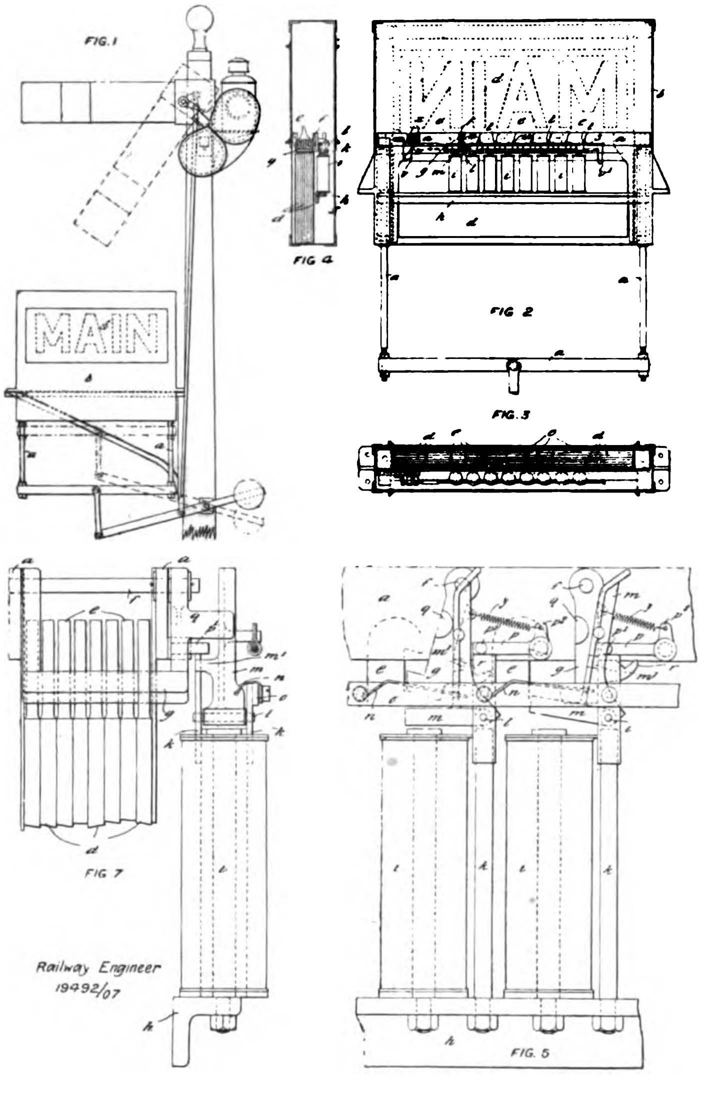
Stanchions for Timber or similar Trucks. *17,444. 30th, July, 1907. W. R. Preston, of J. Stone and Co., Ltd., Deptford, Kent, and R. G. Peckitt, Thornton-le-Moor, Yorkshire.*

The stanchions *a* are hinged at *b* to the underframe *c* and a bracket *d* connected to the frame, so that one flange of the stanchion is held in between the underframe and the bracket, or the stanchion may be pivoted to the low permanent sides *e* if the truck is provided with these latter and in such a manner as to lie in what may be called a "fore and aft" direction when folded down and either entirely horizontally or at a greater or lesser inclination to the horizontal and they are provided with any suitable means for retaining them in their vertical or raised positions such as by pins *f* attached by chains *g* to the extended part d^1 of the bracket or clip *d* or elsewhere to prevent their being lost. The pins *f* are adapted to pass through holes in perforated lugs *h* and *i*, the lug *h* being fixed to the stanchion *a*, while the lug *i* is fixed to extended part d^1 of the bracket or clip *d*. According to another construction and as shown in Figures 5, 6 and 7, the stanchions *a* are made so as to hinge and at the same time are permitted to have a certain amount of motion in the vertical direction to permit of locking and unlocking. In this case the stanchion *a* is provided with a vertical slot *o* and a stud *p* is fixed in the underframe or side *c* of the vehicle and the short bracket *q* on which stud the stanchion is adapted to slide and hinge A stud *r* carried by the stanchion takes into a recess *s* in the top of the side of the waggon, so that when the stanchion is raised the stud *r* clears the slot *s* at the side of the waggon and the stanchion *a* may then be partially rotated until it is in such a position as to be more or less out of the way or flush with the side of the waggon or below it. (*Accepted 30th July, 1907.*)



Combined Semaphores and Line Indicators. *19,492. 30th August, 1907. Siemens Brothers and Co., Ltd., 12, Queen Anne's Gate, Westminster, S.W., and L. D. M. G. Ferreira, 102, Elmbourne Road, Upper Tooting, Surrey.*

This invention has reference to methods of indicating to an engine-driver which of two or more roads is clear when the semaphore is at "line clear," such indication being given by one of a number of boards contained in a casing *b* and raised by



a frame *a*. According to this invention, an improved electro magnetically operated device is provided for selecting the indicating board which is to be raised. Each board has at the top a hook *e*, and adapted to engage with this hook is a hook *g* mounted to turn on a pin *f* extending between the top bars of the frame *a* and projecting through one of these. On a bracket *h* in the casing are mounted electro magnets *i* corresponding in number with the boards, and by the side of each magnet is fixed to the bracket an upright *k* forked at the top to receive the fulcrum *l* of an L shaped armature *m*. In its normal position this armature is tilted away from the magnet core by a spring *n* fixed at one end to a bar *o* and engaging at the other end in a

perforation in the armature. Pivoted to the top bar of the frame a is a pawl p having a lug p^1 which rests on the top of the said longer prong. The tail p^2 of this pawl is connected by a spring y with the corresponding hook g, so that normally the latter abuts against the end of the pawl. In this position of the hook g it is out of registtr with the corresponding hook e so that if the frame were raised the board owning the particular hook e would not be lifted. When the signalman energises a magnet, the armature m is attracted into the position shown on the left hand of fig. 5, in moving into this position the armature comes against a lug q on the hook g, thus moving the latter into register with the corresponding hook e. The frame now ascends and the tension of spring y urges pawl p downwards as it recedes from the prong of the fronk on which it rested, until it engages in the spur r of the hook g. At the same time the hook g which has been kept by the armature in register with hook e, engages the latter and the board begins to rise. When the hook g is free of the armature it is kept engaged with hook e until the frame has descended again, as a result of putting the semaphore to danger, whereupon the pawl p is raised by the prong of the fork and the electro magnet having by this time been de-energised the armature is tilted back again by spring n and the hook g returns to its normal position. (*Accepted 30th July, 1908.*)

COMPLETE SPECIFICATIONS ACCEPTED

A.D. 1907.

6607. Device for reducing the journal friction of locomotives and other rolling stock or other wheeled vehicles. Richards.
12008. Railway signalling apparatus. Saunders, Davis & Griffiths.
13206. Controlling system for electrical circuits. Arthur.
14618. Buffers for railway cars. Pfingstmann.
15336. Latches of railway carriage doors. Preston and Pettigrew.
15675. Automatic railway coupling. Petersen.
15736. Means of locking and unlocking railway carriage and other doors simultaneously. Wilson.
15856. Automatically-acting safety devices for railway carriage doors. Veit and Kindler.
15877. Steel railway sleepers. Sleigh.
15939. Couplings for railway and like vehicles. Dietrich.
16233. Permanent way. Todd, Wade and Jones.
16471. Water coolers for use with condensing locomotive steam engines. Crighton.
16980. Blast pipes of loocmotives. Preston and Worsdell.
17444. Railway and other trucks or vehicles for the transport of timber and similar goods. Preston and Peckitt.
17573. Brakes for railway waggons and other vehicles. Schumacher and Schumacher.
17871. Automatic locking device for railway carriages and other vehicles. Braithwaite, Nicholson, Haynes and Murray.
18130. Brake apparatus for vehicles, such as railway waggons and the like. Hill and Mein.
18285. Means for supporting railway vehicles and applying the brakes in cases of derailment or the like. Gehricke and Bollmann.
18661. Brake for tramcars and other vehicles. Gilfillam.
19472. Automatic locks or latches for railway carriage doors and other purposes. Titterton.
19492. Combined semaphores and indicators for railway signalling. Siemens Bros. and Co. and Ferreira.
19493. Interlocking signal and points levers on railways. Siemens Bros. and Co. and Ferreira.
20859. Automatic signalling between trains. Beutel.
22013. Automatic couplings for railway wagons. Van Duijn.
22572. Sanding gear for tramway or railway vehicles. Cummins.
23135. Vacuum brake apparatus for railway and like vehicles. Gresham and Kiernan.
23177. Railway and road carriage and other sliding windows. Clarke.
23567. Safety apparatus for railway vehicles. Ochschim.
24666. Couplings for railway vehicles. Marillier.
24780. Hose-pipe couplings for railway or like brakes. Windolff.
25086. Means for operating signals on engines on railways and the like. Downs.
25895. Fog-signalling apparatus for railways. Clayton.
26038. Railway rail joints. Williams.
27750. Apparatus for actuating signals on engines on railways and the like. Stratton.
27891. Electrically signalling or communicating messages or signals to vehicles running on rails. Barnett.
27989. Electric railway installations. Woltmann.
28702. Apparatus for railway signalling and for stopping trains independently of drivers. Kuske.
28735. Construction of apparatus for preventing accidents to railway trains. De Bouimistrow.

A.D. 1908.

415. Buffers for railways and like vehicles. Spencer.
1297. Switch mechanism for railway points. Thomson.
1913. Train controlling mechanism for automatically applying the brake. Thompson.
2354. Railway rail joints. Bonner and Bonner.
2532. Stopping of trains on railways. Kuhne.
3418. Brakes for tramway vehicles. Wilkinson.
4336. Air-brakes for railway trains. Powers.
6411. Lubricators for locomotive and other steam engine cylinders. Willans.
6448. Railway rail joints. Rodriguez.
6464. Automatic couplings for railway cars. Berglund and Lindencrona.
6745. Railway buffer stops. Hopson.
7373. Railway rail joints. Wolhaupter.
7580. Electrically-operated signals for railroads. Jones.
7792. Sand distributing apparatus for tramcars, railway trains, motor vehicles, and the like. Sexton and Sexton.
8858. Railway goods waggons. Fried, Krupp Akt-Ges.
9290. Railway frogs or crossings. Justice.
11954. Apparatus for delivering mail bags from railway trains. Saal and Shafer.
12087. Apparatus for adjusting railway vehicle and like brakes. Chavériat.

Official Reports on Recent Accidents.

High Street, Glasgow, Corporation Tramways. *On 3rd January. Col. H. A. Yorke reports that:—*

Car No. 986 got out of control on the hill called Bell of the Brae, between Rotten Row (or Drygate) and St. George St. (or Duke St.), and ran about 1,000 yards, until it came to rest in the Saltmarket near the corner of Steele St., where the gradient is almost flat.

After passing Duke St. the car collided with 8 lorries in succession, two persons were killed and 10 injured, some seriously. The leading end of the tramcar was demolished, the controller being wrenched from its position and thrown backwards against the door of the car. The lorries were more or less damaged, one horse was killed and others injured.

The car was a four-wheeled double-deck car without top cover; it was fitted with the magnetic track brake, hand brake, trigger lifeguard, and one sander at each end.

The only place where the gradients are at all severe is on Bell of the Brae Hill, where there are short lengths of 1 in 16, 1 in 18, and 1 in 20. The speed down this hill is limited by the Board of Trade regulations to 8 miles an hour, and there are compulsory stops at the corner of Rotten Row (or Drygate), and at the corner of Duke Street, these being fixed in order to ensure as far as possible that the speed of cars shall be moderate. About 200 yards above Rotten Row, viz., at the upper corner of Cathedral Square, there is another stopping place; the termination of a ½d. stage, and where there is a Bundy Time Recorder for recording the time at which a car arrives. This is done by the motorman inserting a key, with the number of the car upon it, into the lock of the apparatus; he then turns the key, which causes a bell to ring and the number of the car and the time to be automatically marked on the tape by mechanism inside. When the motorman leaves his car for this purpose he is instructed to remove the reversing handle from the controller. As this handle can only be taken off when it is in the neutral position, and the controller handle in the "off" position, its removal ensures that the electric current is cut off from the car, and that the latter cannot be moved until the driver returns to his place.

As the motorman James Dolan was one who was killed it is difficult to ascertain the cause of this accident. The motormen all testified that the car was in perfect order during the whole time they had charge of it earlier in the day.

Dolan received the car at Mount Florida, and drove it from there to Springburn, back to Mount Florida, and again to Springburn, where it arrived at 4.47 p.m. On reaching Springburn on the last occasion Dolan left the car for a few minutes, and asked a driver named R. McKenzie, who chanced to be there, to take the car across on to the other track ready for the return journey. In order to do this it was necessary to remove both the power handle and the reversing handle from the controller at the Springburn end of the car (No. 1 end), and put them on the controller at the Mount Florida (or No. 2) end. McKenzie found that he could not take off the reversing handle of No. 1 controller, and on Dolan's return spoke to him about it. Dolan replied that he had found something wrong with it as he was passing Cathedral Street* on his last journey to Springburn. In order to take off the reversing handle it is necessary to put it in the neutral or middle position, this being the only position in which it is free. But on this occasion the reversing handle could not be moved from the forward position into the neutral position. While these men, together with conductor Child, were trying to get the handle off, two other men arrived on the scene, viz., time-keeper Falconer and inspector Muirhead. They also tried to release the reversing handle, and failed. They then opened the case of the controller in order to ascertain if possible what was wrong, but were not successful. The car all this time was blocking the track, and inspector Muirhead in his anxiety to clear the road, decided to leave the reversing handle at No. 1 end of the car as it was, and allow the car to return to Mount Florida without a reversing handle at No. 2 end, which then became the leading end of the car Muirhead therefore gave Dolan instructions to this effect at the same time, telling him that the fact that the reversing handle was left in the forward position at No. 1 end would make no difference to the driving or braking of the car (by means of the electro magnetic brake) at No. 2 end. The controller handle was then taken to No. 2 end, and Muirhead having placed the

*It was subsequently found that Dolan had not used the Bundy Time Recorder at this place on this journey to Springburn, probably for the reason that he could not remove his reversing handle.

reversing barrel at that end in the proper position for the journey to Mount Florida, by means of a pair of pliers (a reversing handle not being available), himself drove the car across from the north bound track to the south bound track, where as everything appeared to work satisfactorily, he handed it over to Dolan. Muirhead also told Falconer to telephone to the Langside depot for a fitter to be sent to meet the car at Mount Florida, in order to put the reversing handle right.

Dolan started from Springburn at 4.52 p.m., being a few minutes late. All seems to have gone well until he reached the corner of Cathedral Street, where he should have stopped and operated the Bundy Time Recorder. There is some doubt as to whether he stopped his car at this place; but if he did so, it is clear that the stop was only momentary. It is certain that he did not use the time recorder, probably for the reason that he had no reversing handle at his end of the car, which, as has already been explained, should invariably be removed from the controller and retained by the driver when for any purpose he has occasion to leave his car.† From Cathedral Street to Rotten Row, which is the next stopping place, the distance is 200 yards, and again Dolan, at the corner of Duke Street, failed to stop his car. By this time the speed was estimated at 25 to 30 miles an hour. It was evident at that time that Dolan had entirely lost control of the car, and according to the constable's evidence he was then "blowing his whistle, ringing the bell, and working the two handles" (viz., of the controller and the hand brake). Shortly after this the first and second collisions occurred, the one following immediately after the other, and no doubt Dolan then received his fatal injuries and subsequently fell into the roadway. After this the car proceeded on its journey unchecked, and collided with six other lorries in succession before reaching Glasgow Cross. Conductor Child realised that something had gone wrong, but was unaware that the motorman had been injured or that he had fallen from the car. Child seems to have been occupied in preventing the passengers from jumping off the rear end of the car, and owing to the inside of the car being somewhat crowded he was unable to see what was taking place at the front end. He did not at that time apply his hand brake, because he did not receive the brake signal, viz., four rings on the electric bell, from the driver, and under the circumstances he was right in not applying the hand brake, as he might have skidded the wheels and so have interfered with the action of the magnetic track brake in case this had been applied by the motorman. The car should have stopped at Glasgow Cross, where the tramway crosses two other tram lines and where the traffic is usually very congested. As the gradient was getting flatter the speed was being gradually reduced, and conductor Child, being by that time aware that something serious must have happened to the motorman, applied his hand brake and brought the car to a stand in the Saltmarket. The car did not leave the rails.

An examination of the gear of both the magnetic track brake and the hand brake after the accident indicated, so far as their damaged condition would permit, that no defect had existed in either of them prior to the accident.

Four methods of braking were under normal circumstances available on the car, as explained in the book of Rules and Regulations issued to their men by the Glasgow Corporation, viz., (1) by means of the hand brake; (2) by means of the magnetic track brake; (3) by reversing the motors: the reversing handle being placed in the backward position; (4) by short-circuiting the motors while acting as generators: the reversing handle being placed in the backward position, and the controller handle placed on the highest power notch. This method to be used only as a last resort. Of these (3) and (4) were not available to Dolan owing to the fact that he had no reversing handle at his end of the car.

The rule in Glasgow is that on gradients such as those on the Bell of Brae hill cars should coast down with the magnetic track brake applied sufficiently to maintain the speed at eight miles an hour, but, assuming for a moment that something was wrong with the magnetic brake, there would have been no difficulty whatever in coasting down that hill by the use of the hand brake, had it been applied at the top of the hill at Rotten Row, and the speed never allowed to exceed the 8 mile limit. In either case the brake should be applied while the car is at rest at the top of the hill. Judging from constable Donald's evidence, Dolan was using both the magnetic brake and the hand brake at the time of the collision. If the speed was then anything like 25 to 30 miles an hour the hand brake would be practically useless, and the only result of applying it would be to interfere with the action of the magnetic track brake by causing the wheels to skid. And although the track brake, if properly used, would be able to stop a car travelling at that speed, given sufficient time or distance, it seems that the first collision occurred before any reduction of speed could have been effected. Had the reversing handle been available at the front end of the car it is probable that Dolan, following the usual custom, would, if time had permitted, have made use of No. (4) method of braking, which, as already stated, is to be used only as a last resort. This method is in reality nothing more than another form of wheel brakes, the power of which is limited by the co-efficient of friction between the wheels and the rails, and it is not nearly so effective as No. (2). Under these circumstances the fact that Dolan was unable to use No. (4) method of braking had any bearing upon the accident, inasmuch as this method would not have had time to take effect before the collisions occurred and Dolan received his fatal injuries.

†Dolan's Bundy key has not been found since the accident. It may have slipped out of his pocket when he fell from the car.

When the car came to rest the hand brake was found to be off and the controller handle in the full braking position, the effect of which would be to apply the magnetic track brake with full force. But as the front end of the car was very much damaged it is impossible to say definitely whether the handles were in these positions when Dolan fell off the car. The question therefore arises, "Did the magnetic track brake fail him"?

No. 90 pattern of controller differs from other tramway controllers in that the movement of the reversing handle does not directly mov the reverse drum itself, this not being actually rotated until the main handle is moved from the "off" position towards either the power or the brake notches. The ratio of the gear by means of which the reverse drum is rotated by the movement of the main drum, is such that a very slight movement of the main (controller) handle causes the contacts of the reverse drum to make connection with their corresponding fingers.

The wiring of an electric car is very complicated and difficult to follow, even with the aid of a diagram, without which it is impossible. But it may be briefly stated that the placing of the reversing key of the controller in the forward position at one end of the car has, so long as the handle of the controller at that end is accurately in the "off" position, absolutely no effect upon the driving or braking of the car by means of the controller at the other end. But if by any chance the controller handle at the first end is displaced even to a small extent towards the brake notches, contact is made between the reversing drum and its corresponding fingers, with the result that when the controller handle at the other end is moved to the braking position the armatures of the motors are short circuited and the magnetic track brake cannot be applied. Similarly if the main handle at one end of the car is slightly displaced towards the driving notches, the reversing key being as before, it would prevent the car from being started by means of the controller at the other end.

If, when inspector Muirhead told Dolan to remove the controller handle from No. 1 end of his car to the other end the pointer was exactly in the "off" position he was right in saying that the reversing handle at No. 1 end of the car being left in the forward position would make no difference whatever to the driving or braking of the car by means of the controller at No. 2 end. But if in removing the controller handle from No. 1 end it was displaced even to a very slight degree (say from ¼ to ⅜ inch) in the direction of the braking notches, it would render it impossible to operate the magnetic brake from the controller at No. 2 end. When the reversing key is in any but the neutral position the controller handle is free to move in either direction, and a slight displacement of the controller handle might easily take place unobserved during the process of removing that handle.

Should anything of this sort have happened when the men were hurriedly removing the handle from one end of the car to the other at Springburn, it is possible that when Dolan came to apply his magnetic track brake on the Bell of the Brae hill it did not operate, not on account of any defect in it, but simply because the electrical connections were wrongly made. This would take him by surprise, and not knowing the reason for the failure of the brake he might have made more than one attempt to apply it. By the time he realised that for some reason, which he did not understand, the magnetic brake was out of use, the speed would have got beyond the power of the hand brake, and the car would then be out of control.

Whether this be the correct explanation or not, inspector Muirhead committed a grave error of judgement in allowing the car to leave Springburn with the reversing handle in the forward position at the rear end of the car, and without any reversing handle at the driving end. For, disregarding altogether the suggestion made above, it is not to be disputed that Dolan was deprived of the third and fourth methods of braking the car which are specified in the Glasgow Tramway Rule Book, and although if these methods of braking had been available the accident would not have been altogether averted, as the collisions would have occurred before either of those methods had time to take effect, Muirhead had no right to cause, or permit, Dolan to run any risks. A heavy double-decked tramcar is at all times an awkward thing to manage on an incline, and not a single precaution can be safely dispensed with. Muirhead's duty, and Dolan's duty if Muirhead had not happened to be present, was to cause the car to be taken to the nearest depôt as soon as the difficulty with the reversing handle occurred. It happened in this case that there was a depôt at Possil Park, not very far from Springburn, and, if the car had been sent there, there would have been no occasion for it to descend the hill until the defect had been put right.

It is quite easy to guard against the possibility of removing the controller handle when it is not absolutely in the "off" position by casting on the lid of the controller case an overhanging lip round the spindle of the main drum, with only one gap in it, viz., immediately opposite the "off" position, attaching at the same time to the handle a lug which would engage in the lip in such a way that the handle could only be put on or taken from the controller in the correct position. Such a lip is provided on controllers of other types, and the manufacturers (the British Westinghouse Company) agreed to act upon this recommendation in future when manufacturing controllers of No. 90 pattern.

When the case of the controller was opened after the accident the whole difficulty was found to be due to the screw pivot stud at the top of the reverse interlocking pawl having become unscrewed, thus allowing the pawl to get out of position and preventing it from passing through the slot in the sprocket wheel, the result being that the inter-

locking gear became jammed and the reverse handle could not be moved in either direction. This is not the first occasion on which the pivot studs, either at the top or bottom of the pawl, have worked loose. The defect is easily remedied, either by inserting a small plug of wood or metal in the pivot hole on the top of the pivot stud, or, better still, by lengthening the pivot stud itself, and the manufacturers promised to attend to it.

As already stated, it is the custom on the Glasgow Corporation Tramways to use the hand brake for ordinary stops, and to reserve the magnetic track brake for emergency stops and when coasting down hills. This is not the proper manner in which to employ the magnetic or any other form of "power" brake. It is a mistake in tramway practice to regard any brake as an "emergency" brake, and as one which is only to be used on rare occasions. When this custom is followed, there is a risk that the brake will either be wrongly applied, or for some reason or other will fail when the occasion for its use arises. In tramcar driving the "emergency" is ever present, and the motormen should be instructed to use at all times the most powerful braking device at their disposal.

The tramcar to which this accident occurred, and most of the tramcars belonging to the Glasgow Corporation, are fitted with only two sand-boxes—viz., one at each end of the car. This means that sand can be applied to only one rail at a time, so that when the rails are greasy, and the efficiency of the braking appliances is of the utmost importance, it happens that the brakes, of whatever description, only do good work on one side of the car, which in other words means that when the rail conditions are at their worst only half the brake power is available. This seems to be a very unsatisfactory arrangement, and the Glasgow Corporation should take early steps to fit all their cars with four sanders—viz., two at each end.

*

At **Clapham Common Station, C. & S.L.R.** *On 24th May. Mr. A. P. Trotter reports that*:—

An electric locomotive belonging to the City and South London R. was destroyed by fire.

There seems to be no evidence to show that the fire was due either directly or indirectly to the electric current, and it is impossible to connect it with any electrical cause. It seems to have burned most fiercely at the corner where a cupboard stands, and at the opposite corner where there is a considerable collection of insulated cables. The contents, including controllers, and other machinery above the floor level were destroyed. A little woodwork remained not quite burned, and this was extinguished by the firemen. The amount of wood has been reduced in the newer locomotives. The carriage next to the locomotive was uninjured inside; the glass of the door was broken by heat, and the paint blistered.

If any servants of the Co. had been present when the fire first broke out, it could have been extinguished in a few minutes. The current was cut off at 12.20 a.m. and the fire was not noticed till 7.30 a.m. But being allowed to burn itself almost out, it afforded an interesting and satisfactory test. The wooden platform showed no traces whatever, and the only signs that there had been a fire was a little smoke on the roof, split tiles, and the partial burning of a few feet of wood moulding round the advertisements. The complete escape of the carriage coupled to the locomotive is a point in favour of separate locomotives.

The cause may have been, (1) a lighted match thrown down by a man just before leaving, or (2) the emergency oil lamp which may not have been extinguished, or (3) spontaneous firing of oily waste in the cupboard. No large amount of oily waste is kept on the locomotives, and spontaneous firing does not occur with small quantities.

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Between **Tividale & Oldbury, Birmingham & Midland Tramways.** *On 20th February. Col. H. A. Yorke reports that*:—

Car No. 6 left the rails and after travelling a few yards on the ground turned over on its left side and fell upon conductor McCabe and killed him. There were about 16 passengers on the car of whom 9 were injured, one fatally.

The car was a four wheel (6ft. 6in. centres) double deck car with top cover. It was fitted with the hand brake, electric (rheostatic) brake, trigger lifeguard, and four sanders, viz., two at each end. It had recently undergone general overhauling and painting, the wheels being changed.

The tramway was originally worked by steam, but was reconstructed for electric traction on the overhead system in 1904.

The track was in good condition, although there were some slight irregularities such as are to be found on all tramways. Owing to the section of the road, the left hand rail at the points is slightly lower than the right hand one, and this difference increases for a short distance along the loop. But, speaking generally, there was little fault to be found with the permanent way.

After the accident the left hand trailing wheel was found to be broken, and from the marks on the ground it appears that this wheel broke as it was passing through the points. This caused the left hand trailing corner of the car to drop and the leading end to slew slightly to the right. The result of this was that right hand leading wheel took the wrong side of the crossing where the inner rails of the two tracks intersect. The leading end then became derailed, and the car swerved still more to the right until it was right across both tracks, when it turned over.

The accident may be attributed to the breaking of the wheel, which was of cast iron with a steel tyre, the cast iron centre being similar in design to other centres that have been in use on these tramways since their opening for electric traction. It was not one of the original centres, but formed one of a batch supplied by the Steel Nut and Joseph Hampton Co. in 1905. In the centre of each spoke there was what appeared to be a thin iron rod extending from the rim to the hub. These rods were not specified for, and seem to have been put there by the manufacturers. The spokes were rather light, and it was probably for this reason that the manufacturers caused the iron rods to be placed in the middle of the spokes during the casting. The wheel, the tyre of which had been recently turned up, was first brought into use in December, 1906, since which date it is said to have travelled about 25,500 miles. It had been placed under the car, to which the accident occurred, during its repairs a short time previously.

When the car entered the loop points and the wheel had to travel on its flanges for a short distance, as is always the case at such points, the spokes gave way, and the wheel collapsed. The Co. had, before the accident, decided to gradually discard them and replace them by wheels of a stronger and better description. But since the accident, they have agreed to hasten the process of scrapping these unsatisfactory wheels, and to replace them as quickly as they can obtain supplies of the improved wheels from the makers.

Books, Papers and Pamphlets.

RECEIVED.

The Fixing of Rates and Fares. By H. MARRIOTT, assistant traffic manager, Lancashire and Yorkshire Railway. London: "The Railway Gazette," Queen Anne's Chambers, Westminster. 1908. [85 pp.; 8¾ by 5¾; price 2s. net.]

Railways and Nationalisation. By EDWIN A. PRATT. London: P. S. King and Son, Orchard House, Westminster. 1908. [455 p.; 7½ by 4¾; price 2s. 6d. net.]

Railway Track and Track Work. By E. E. RUSSELL TRATMAN, A.M.Am.Soc.C.E., Mem.Am.Ry.Eng. and M. of Way Assoc. 3rd edition, fully revised. With 232 illustrations, 44 tables, and an appendix of statistics of standard track construction on American railways. New York: The Engineering News Publishing Co. London: Archibald Constable and Co., 10, Orange Street, Leicester Square, W.C. 1908. [520 pp.; 8¾ by 5¾ and 4 folding tables and xix. pp. index; price 14s. net.]

The Railway Locomotive: what it is and why it is what it is. By VAUGHAN PENDRED, M.I.Mech.E., M.I. and S.Inst. Illustrated. London: Archibald Constable and Co., Ltd., 10, Orange Street, W.C. [310 pp.; 8¼ by 5¼; price 6s. net.]

Fowler's Mechanics' and Machinists' Pocket Book and Diary, 1909. A synopsis of practical rules for fitters, turners, millwrights, erectors, pattern makers, foundry men, draughtsmen, apprentices, students, etc. Edited by W. H. FOWLER, Wh.Sc., M.Inst.C.E., M.I.Mech.E., M. Iron and Steel Inst. Scientific Publishing Co., Manchester. [448 pp.; 6¼ by 3¾; price 6d. net.]

The Modification of Illinois Coal by Low Temperature Distillation. By S. W. PARR and C. K. FRANCIS.

Lighting Country Homes by Private Electric Plants. By T. H. AMRINE. Bulletins Nos. 24 and 25 of 48 and 35 pp. respectively. Illustrated. Published by the University of Illinois Engineering Experiment Station, Urbana, Ill., U.S.A.

British Standard Specifications. No. 40. Cast-iron Spigot and Socket Low-pressure Heating Pipes. No. 41. Cast-iron Spigot and Socket Flue or Smoke Pipes. London: Crosby, Lockwood and Son, 7, Stationers' Hall Court, E.C. [13½ by 8½; price 2s. 6d. net each.] Both specifications stipulate that no pipe shall have a bore of less than the nominal diameter, as is at present very often the case. The specifications also require the pipes to be marked with distinctive class letters to show the purposes for which they were made, and also with the manufacturers' trade mark or initials for the purpose of identification. Standard dimensions and designs for the soot doors of the various sizes of pipe are given in the specification for flue or smoke pipes, and both specifications are complete with tables of dimensions of the standard pipes and fittings.

Molesworth's Pocket Book of Engineering Formulæ. By SIR GUILFORD L. MOLESWORTH, K.C.I.E., and HY. BRIDGES MOLESWORTH. 26th edition: revised and enlarged with an electrical supplement by WALTER H. MOLESWORTH. London: E. and F. N. Spon, Ltd., 57, Haymarket. New York: Spon and Chamberlain. 1908. [901 pp.; 4¾ by 3 by ¾ thick; India paper, leather, gilt edges; price 5s. net.]

Alternating Currents Simply Explained. An elementary handbook on alternating current generators, transformers, and motors. By ALFRED W. MARSHALL. London: Percival Marshall and Co., 26-29, Poppin's Court, E.C. [82 pp.; 7¼ by 4¾; price 6d. net.]

EDITOR'S NOTICE.—All manuscripts and communications should be distinctly written, or preferably type-written, on one side of the paper only, and addressed to the Editor 3, Ludgate Circus Buildings, London, E.C. The Editor cannot undertake to return rejected manuscripts or drawings unless accompanied by a stamped directed envelope.

PUBLISHER'S NOTICE.—All communications relating to the Publisher's Department Advertisements, Subscriptions, &c., should be addressed to the Publisher, 3, Ludgate Circus Buildings, London, E.C. All Cheques, Drafts, Post Office Orders, &c., should be made payable to the order of the Proprietors of *The Railway Engineer*, and be crossed "Capital and Counties Bank, Limited." Alterations to standing advertisements must be received by the first post on the 22nd of the month, excepting February and December, when they must be received on the 20th.

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THE
Railway Engineer

VOLUME XXIX., No. 347. *DECEMBER*, 1908.

Contents.

The Rt. Hon. Lord Stalbridge, chairman of the L. and North-Western R., has consented to take the chair at the Festival Dinner of the Railwaymen's Convalescent Home, to be held in the spring of next year.

Mr. Stanley Baldwin, M.P., of Baldwins, Ltd., has been elected a director of the Great Western R., to fill the vacancy caused by the death of Colonel Sir Nigel Kingscote. Mr. Baldwin is a son of the late chairman.

Mr. Herbert Allen has been elected vice-chairman of the Costa Rica R., in succession to the late Mr. Alfred R. Smith.

Sir W. E. Garstin, G.C.M.G., member of the Railway Board of Egypt, has been elected chairman of the Egyptian Delta Light Railways.

The Rt. Hon. Lord Balfour of Burleigh, director, has been elected chairman of the San Paulo (Brazilian) R., in succession to the late Mr. M. G. Megaw.

Mr. F. J. Ramsden has been elected a director of the Furness R., in succession to the late Sir John Hibbert.

Railway honours in commemoration of the King's birthday were far from numerous. Perhaps it was feared that offence might be given to Mr. R. Bell, M.P., and his party, but **Sir Chas. McLaren, Bart., M.P.,** chairman of the Metropolitan R. and several other important commercial undertakings, was created a Privy Councillor, and **Mr. H A. F. Currie,** manager of the Uganda R., had the honour of C.M.G. conferred on him.

Mr. Wm. Forbes, general manager L., Brighton and S.C.R., has been elected chairman of the Railway Clearing House General Managers' Conferences for next year.

Lt.-Col. Hy. Plews, general manager of the Great Northern R. of Ireland, has been elected chairman of the Managers' Conferences of the Irish Railway Clearing House for next year.

Mr. J. Elliott, superintendent of the line, Midland R., has been elected chairman of the Railway Clearing House Superintendents' Conferences for the ensuing year, and **Mr. F. H. Dent,** goods manager of the South-Eastern R., chairman of the Goods Managers' Conferences.

Mr. Russell Willmott (vice Mr. J. F. Burke), of the East and West Junction R., and **Mr. Joshua Shaw** (vice Mr. R. Bowman Smith), of the Mersey R., have been appointed members of the Goods Managers' Conference, Railway Clearing House.

Mr. T. W. Pettigrew has been appointed general superintendent of the Caledonian R., in succession to Mr. Guy Calthrop, who, as we noted in our last issue, has succeeded the late Mr. R. Millar as general manager. Mr. Pettigrew entered the service of the company as a clerk over 40 years ago. He has been succeeded as assistant general superintendent by **Mr. R. Docherty,** who for some time has had charge of the goods and mineral department of the office.

Mr. A. J. Constable, formerly assistant to the general manager of the Great Northern R., subsequently assistant to general manager of the Central South African railways, and latterly of the Midland R., has been appointed by the South Yorkshire Joint Line Committee superintendent of the new joint line from Dinnington to Kirk Sandall.

Mr. B. H. Peter, signal engineer, Met.-District R., has been appointed signal engineer to the Underground Electric R. Co. of London.

Mr. W. Kettles, chief clerk, has been appointed district traffic superintendent of the North British R. at Dundee, in succession to the late Mr. W. B. Cape.

*

Proposed Amalgamation of the Taff Vale, Rhymney and Cardiff Railways.

SUBJECT to Parliamentary sanction, the Taff Vale R. Co. has agreed to buy the undertakings of the Rhymney and the Cardiff railway companies. The amalgamation would have only a very local interest so far as the country is concerned, but great economies would be effected in working the three undertakings by one administration.

*

Stratfordians' Re-union Dinner.

THE fifth annual re-union dinner of the past and present staff of the locomotive department of the Great Eastern R. was held at the Liverpool Street Hotel on the 20th ultimo, with Mr. W. F. Pettigrew, locomotive superintendent of the Furness R., in the chair. The re-union numbered 60, and included Messrs. James Holden, J.P., S. D. Holden, A. J. Hill, F. V. Russell, W. D. Craig, E. S. Tiddeman, J. H. Adams, J. W. Howard, A. W. Polley (Hon. Secretary of the Organising Committee), and other distinguished Stratfordians.

Cardboard Models of Locomotives.

The Publishers of "The Model Engineer" are issuing at the very moderate price of 1*s.*, a box containing a set of cards which, when cut up and stuck together in accordance with a book of very explicit instructions, will form an exact scale model of the Midland engine "Princess of Wales." Building such models is a very useful and instructive pastime for children during the long winter evenings. The methods employed in putting this model together are very ingenious.

*

French Colonial Railways.

The recent report dealing with the French Colonial Budget for 1909 contains some interesting details concerning the development of railway construction in the French Colonies from 1895 to 1908. The total length open to traffic in 1895 was 272 miles, in 1900 it was 590 miles, in 1905 it had risen to 1,651 miles, and on June 30th, 1908, to 2,066 miles. And including the railways in course of construction (with the exception of those in Tunis and Algeria) the total length amounted to 2,923 miles.

The results obtained by the lines already in full working order are very satisfactory both as regards the receipts and the development that they have caused in the districts through which they have been laid. This development is being seen most notably in Western Africa. However, attention is called to the one great fault in connection with the French Colonial railways, viz., that the construction of the lines is allowed to depend too much upon financial considerations, the result being that far too many alterations to the original projects have to be made.

*

Freeing Points and Crossings of Snow.

A new method of snow melting by means of a hydrocarbon fluid was described in a paper presented by J. S. Lang, M.Am.Soc.M.E., at a recent meeting of the Railway Signal Association. The practicability of this method, according to Mr. Lang, has been demonstrated by its use for the purpose of freeing switches from snow and ice during the past three winters at one of the busiest terminals in the country. The process is described as follows:—

The melting of the snow or ice is effected by applying to it a flaming fluid of special character, which continued to burn while in the snow, melting and finally evaporating the greater portion of it. On account of the special character of the fluid, the flame is easily maintained regardless of the high winds of the storm or the drifting of the snow.

The fluid is applied by the regular track men by means of a safety distributing can, and the height and extent of the flame can be regulated with ease.

No injury to track results from the use of this system. as the temperature of the rail is not raised to the usual summer heat. The fluid is obtainable in the open market at from 3 to 5 cents (1½*d.* to 2½*d.*) per gallon, and may be obtained free of cost by railroads operating their own Pintsch gas plant.

This system is said to be at once more economical and more effective than the common method of "hand cleaning" switches.—*American Engineer and Railroad Journal.*

*

Russian Railway Notes.

According to the Russian Press, the State Railways have been worked at a loss for several years, while the railways owned by private companies have been able to continue their services only by the help of heavy subsidies from the guarantee funds provided by the Government. It is not surprising, therefore, that the Minister of Finance should have appointed a Commission to discuss the measures that ought to be taken for reducing the expenditure and improving the general working and the receipts of the railways. During the first eight months of the present year the receipts of State Railways amounted to £36,975,000, or a decrease of £850,000, as compared with the corresponding period of 1907.

The Russian Ministry of Ways of Communication has asked the Duma to make it a grant of £2,125,000 for the purpose of buying new rolling stock for the State railways during 1909, and has just issued orders that henceforth "engineer-technologists" will not be admitted to service on any Russian railway unless they have served at least six months as drivers on locomotives.

A striking instance of the general insecurity of property on the Russian railways has just occurred in St. Petersburg, and is recorded by the "Journal de St. Pétersbourg." A breakdown train belonging to the St. Petersburg-Moscow section of the Nicolas Railway was recently pillaged during the night. The trucks were all locked by especially strong locks and bolts, and stood on a siding ready for use.

*

Testing Ferro-Concrete Floors.

Some interesting tests of Ferro-Concrete (Hennebique system) Floors were recently made at the new Sorting Office of the General Post Office by Messrs. L. G. Mouchel and Partners, consulting engineers, who are jointly responsible with Sir Henry Tanner, principal architect to H.M. Office of Works, for the design and construction of the new buildings.

The portion of the floor tested was one complete bay with the superficial area of 40ft. by 35ft., or 1,400 sq. ft., consisting of six secondary beams 8in. wide by 18in. leep, excluding the floor slab, which is 3½in. thick. The beams are spaced 5ft. 10in. apart centres and have the span of 40ft. between the centres of the supporting beams and columns. The secondary beams are reinforced by four 1⅜in. diam. tension bars, two ⅞in. diam. compression bars, and numerous stirrups for resisting diagonal tension and shearing stresses. The floor slab is reinforced by ⅜in. diam. tension bars running in two directions at right angles to one another as well as by stirrups like those in the beams. The concrete was made in the proportion of 6 cwt. Portland Cement, 13½ cu. ft. clean sharp sand and 27 cu. ft. washed gravel, crushed to pass through a ¾in. diam. gauge. At the date of the tests the work had been completed about four months.

The floor was designed for the working superload of 1cwt. per sq. ft., and the specification required that

(*a*) The maximum deflection at the centre of the beams to be not more than 1-600th of the span under the full test load of 1½cwt. per sq. ft.

(*b*) After imposition of the full test load, the normal working to be left in position for the period of 12 hours and the resulting deflection to be again measured.

Under the normal load of 1cwt. per sq. ft. the following results were observed by means of delicately adjusted instruments:—

Beam No.	Deflection in 64ths inch. Total.	At supports.	Net.	Ratio to Span.
1	15	1	14	1 to 2140
2	13	—	13	1 to 2300
3	12	1	11	1 to 2730
Under the full load of 1½cwt. per sq. ft.:				
1	22	2	30	1 to 1500
2	20	—	30	1 to 1500
3	20	2	18	1 to 1670

After 12 hours the extra load was removed at 9 p.m., when all the beams immediately rose about $\frac{3}{64}$ in. at the middle of the span, and readings taken 9½ and 12 hours subsequently showed that the beams had not perceptibly altered.

After two hours (11 a.m. day following commencement of test) the removal of normal load began, and by 5 p.m., when one-third of it had been taken off, the average rise of the beams was more than $\frac{9}{64}$ in. By 8.30 a.m., when half the load was off, the beams rose $\frac{3}{64}$ in. at the middle, and at 10.45 a.m., when the floor was quite cleared, the instruments showed that the floor had regained its original form.

Books, Papers and Pamphlets.

Railway Shop up to Date. Compiled by the editorial staff of the "Railway Master Mechanic." London: Archibald Constable and Co., Ltd.

This is a reference book of American Railway-Shop Practice, and has been compiled by Messrs. M. H. Haig and B. W. Benedict, managing editor and editor respectively of the "Railway Master Mechanic" (which is a description unknown in this country, but which is roughly equivalent to "locomotive superintendent," minus the running department), with the assistance of an advisory committee, consisting of Mr. C. A. Schroyer, superintendent car department, Chicago and North-Western R.; Mr. M. K. Barnum, mechanical expert, Chicago, Burlington and Quincy RR.; and Mr. R. D. Smith, mechanical expert, New York Central Lines.

When reviewing a book of reference on such an important subject as the laying-out and arrangement of railway shops it is highly necessary to examine the auspices under which it is produced, and in this instance it must be admitted that in the combinaton of the three gentlemen above named (representing, as they do, vast American railway systems) and the editorial staff of one of the leading railway technical papers and one which, moreover, is especially devoted to the particular field covered by the book, we have all the elements necessary for the production of a reliable work of reference. We know of no other book like it in the English language; we can strongly recommend it as an interesting and most useful addition to the bookshelf of every railway engineer. It should also be particularly useful to those civil engineers who lay out shops without any very extensive knowledge of the mechanical processes and their sequences which are to be carried out in them. In America there is, compared with this country, plenty of room and as a rule the works planner is not cramped for space, but there are other large countries—India, Africa, China and South America, and in these countries the book should be of great value. On the Continent those who are unable to read the text will have no difficulty in reading the many excellent drawings. The book does not, and of course no book could, supply particular local knowledge or special arrangements required by climatic or other peculiar conditions.

The various shops are dealt with in the following order: Lay-out, Locomotive Shop, Blacksmith Shop, Freight Car Shop, Passenger Coach and Paint Shop, Planing Mill, Foundry, Power Plant, Storehouse, Round House. The method of each of the chapters is the same; the general conditions are first tersely discussed and then brief descriptions are given of several selected shops, followed by illustrations of the same, *e.g.*, the chapter on Lay-outs is followed by no less than 21 general plans of railway works.

At the end of the book is a long list, covering more than 5 pp., of references to articles in the American technical papers describing railway shops.

*

The Application of Highly Superheated Steam to Locomotives. By ROBERT GARBE. London: Crosby, Lockwood and Son.

This book is a revised reprint of a series of articles which appeared in *The Engineer* and which have been edited by Mr. Leslie S. Robertson. The author is one of the engineers attached to the Berlin section, or "direction," of the Prussian State Railways, which are also the home of the well-known Schmidt superheater, an appliance which has made very rapid and large progress in Germany, slow progress elsewhere, and very slow progress in this country, France and America.

The book is devoted firstly to showing the advantages of highly superheating steam for increasing the power of locomotives as against the use of high steam pressures and three or four cylinders, either simple or compound, and secondly to showing that the Schmidt superheater, which is very fully described and illustrated, is superior to all the other superheaters, which are briefly described and illustrated, and which have what the author considers their defects pointed out with directness and brevity.

The saving claimed for a locomotive using highly superheated steam is 25 per cent., as compared with an ordinary and similar locomotive of the same weight, and 20 per cent. as compared with a compound locomotive. In addition, superheating enables an engine to run longer distances without taking in water, reduces the maintenance (repairs and washing out) of boilers very considerably as compared with high pressures and compounding. These are great claims, and the value of the book would have been much enhanced had more proof of them than the statement that "trials made "with superheated locomotives on the Prussian State Rail- "ways leave no doubt as to their superiority over the heavier "four-cylinder compounds," been given.

The book is well written, and those who wish to learn the case for high superheating, especially by means of the Schmidt superheater, will do well to obtain the book, as it could not be more clearly or succinctly stated.

*

Tests of Reinforced Concrete Columns Series of 1907. By Prof. ARTHUR N. TALBOT. Bulletin No. 20 of the University of Illinois Engineering Experiment Station, Urbana, Ill.

This bulletin records experiments upon concrete and reinforced concrete columns, which have already become quite notable and which will have a marked influence in fixing the standing of certain types of construction. A feature of reinforced concrete in which engineers and architects are much interested is the column having the concrete hooped or bound with steel bands or spirals. Tests on this form of column reported from France and Germany indicate great strength, but the results have not been considered conclusive and many questions have been raised concerning its applicability to general construction. Engineers have wanted to know more of the action of this new combination of material. The tests here reported will therefore be welcomed by the engineering profession. One of the leading engineering journals in commenting on the importance of the results of these tests states that they bear on nearly every phase of importance of reinforced concrete columns. The tests go to show that in hooped columns the steel hooping does not come into action to any great extent before a load equivalent to the ultimate strength of plain concrete, or a little below, is reached, and that up to this point the action of the column is very like one of plain concrete. Beyond this load the column shortens rapidly and the deformation becomes very marked. The extreme amount of shortening is a great disadvantage. The amount of strength added by the hooping before ultimate failure is reached is two to three times as much as the effect of an equal amount of longitudinal reinforcement. A discussion of the French and German experiments is made, and observations on Poisson's ratio and data on the phenomena accompanying tests of plain concrete columns are given. The work of Professor Talbot in reinforced concrete is well known, and this investigation is a further evidence of the importance of the work of the Engineering Experiment Station. The bulletin contains 60 pages.

*

The Fixing of Rates and Fares. By H. MARRIOTT, assistant traffic manager, Lancashire and Yorkshire Railway. Lecturer, Faculty of Commerce in the Victoria University of Manchester. London: *The Railway Gazette.* 1908.

Until about 12 or 14 years ago Mr. Marriott, who has recently been promoted to the position of Superintendent of the Line, was in the audit office of the Lancashire and Yorkshire R., and is therefore an authority on the question of rates and fares. There are many railway men, to say nothing of the general public, who are unacquainted with the method of arriving at fares. They know that the general rule is one penny per mile, but are more or less ignorant as to the shorter route governing the fare between competing points, and they are not much, if any, wiser as to the maximum rates allowed by the Railway and Canal Traffic Acts and of the different classes into which merchandise is

divided. Railway students and the public may therefore congratulate themselves that they have now such a ready means of obtaining an insight into a complicated subject. But Mr. Marriott also deals in an equally interesting manner with tourist and excursion fares, season and traders' tickets and workmen's fares.

No one would wish to be hypercritical with such a useful and excellent book, but we thin kit is to be regretted that some light was not thrown on the fixing of rates and fares between competing companies, especially as to the cheap fares between Lancashire and London, by the Clearing House Committees. And the Normanton Conference would also have been an interesting subject. The author not unnaturally refrains from referring to the thorny question of "owner's risk" except in one paragraph of eight lines, and then it is only mentioned as "exceptional rates." These are, however, omissions which could be rectified in future editions, and which do not very materially detract from the value of the present work.

*

Railways and Nationalisation. By EDWIN A. PRATT. London: P. S. King and Son. 1908.

As the question of the nationalisation of British railways is to the front just now, it is a decided convenience to have such a real live book at hand as that before us, as it is comprehensive, instructive and clear. Many persons assume that because municipalities more or less—chiefly less—successfully operate tramways, gas works, electrical undertakings, etc., that the British Government could successfully run railways, and they point, in support of their assumption, to the State-owned railways of New Zealand, Australia, Germany, Belgium, and other countries. Opponents of railway nationalisation are generally content to offer as an answer to this the question of cost and the possible fear of a host of railway men capturing the parliamentary machine. Mr. Pratt's reply to State-ownership proposals covers a wider and more comprehensive ground. He brings the question nearer home, and shows how the passenger and trader would suffer at the hands of high Government officials "bound by official routine and circumlocution in general." No one's convenience or interest will be studied then, and whilst all are thus placed on the same level it is a much lower level than we rest upon now. Then there are many difficulties, which cannot readily be swept aside as being matters of detail, to be met with. They are problems to be faced, and are of a nature that have not been thought of by advocates of nationalisation, *e.g.*, there are the railway shops at Crewe, Swindon, Derby, Doncaster, and other places. These will still be necessary for the repair of locomotives and rolling-stock, and there are the railway-owned docks and steamship services. These would, it may be assumed, be taken over by the State, who thus enter into competition with private parties and come into contact with trades unions who might call out their employes in a sympathetic strike and so involve the Government. These and similar problems are pithily exposed, and, incidentally, the public is reminded of the many advantages it now enjoys under private ownership.

*

The Nationalisation of Railways. By A. EMIL DAVIES. London: A. and C. Black. 1908.

This booklet has at any rate two merits. Firstly, like the proverbial baby, there is not much of it, and secondly, what there is of it is, we think, more likely to retard than advance the cause it advocates. Generally it may be said that the author finds nothing good in or about our railways and their management whereas the Prussian State railways approach the acme of perfection. It seems almost a pity that the author does not permanently reside in Germany, as he would then be able to enjoy more frequently the "excellent meals at 1*s.* 5*d.*, and consisting of "soup, cutlets and vegetables, pastry, a cup of coffee, and a cigar." The mention of that cigar reminds us of the prizes once offered in an angling competition, viz., 1st prize, a pot of beer; 2nd prize, half a pot of beer; and 3rd prize, a good cigar.

It is, however, fair to point out that Mr. Davies is the author of but a portion of the book, as it consists largely of ill-assorted extracts from speeches of more or less public men and articles from papers; about one-sixth of the book consists of extracts from the Hon. Geo. Peel's futile attack on the L. and North Western R. management.

The personal opinions of Mr. Davies as to the merits of British and Continental methods might have carried more weight had his statement of facts been more reliable. Thus we are told that we have "three or four times the amount of rolling stock that the traffic really requires," that "an ordinary locomotive" costs about £2,500, a 3rd class coach £400, "a 1st class one £700, while a composite coach works out at about £1,000," and that one general manager is paid a salary of £12,000. Had we space we could pick similar statements from almost every page of the author's work.

There is, however, one other statement which calls for particular mention. On page 36 the author remarks that he knows of "one case in which a certain railway secures all "traffic of a large engineering concern because the canvasser "has put them up to dodges in classification which are "winked at by his company, solely in order to secure the "traffic at the expense of competing lines." Such a proceeding would not be tolerated by the Clearing House, which by the way the author is so anxious to see abolished, and as a consequence its army of clerks sent to join the unemployed. It would also be preferential treatment which would be stopped by the Railway and Canal Commission Court, and lastly we would point out that it ought to be within the knowledge of the author that not long ago both the L. and North-Western and the Midland Co.'s successfully instituted proceedings against certain firms for falsely describing their consignments. The line between "dodges in classification" and fraud is a very fine one, and respectable firms do not care to take the risk of being found on the wrong side of it.

Locomotive Notes.

THIS year has not been remarkable for the number of new locomotive designs which have been introduced on British railways; in fact, speaking generally, the locomotive departments have been marking time. This is doubtless due in some extent to the heavy falling off of traffic owing to the trade decline, but another reason for this state of things is to be found in the fact that the existing engines, which were built during the last four or five years, are of such proportions as to be well up to the traffic demands, and thus the need for greater power has not arisen.

Some new types have, however, been introduced, and we have dealt with them in our monthly "Notes," and others which deserve notice are the new 0-6-0 type goods engines, which have recently been put into service on the Caledonian and the Great Northern Railways.

The principal dimensions of this and the Caledonian engines are as follows:—

Railway.	Caledonian.	Great Northern.
Cylinders	18½ in. x 26 in.	18 in. x 26 in.
Wheels, diameter...	5 ft. 0 in.	5 ft. 8 in.
Wheelbase	16 ft. 9 in.	16 ft. 3 in.
Boiler, barrel diameter	4 ft. 8⅛ in.	4 ft. 8 in.
,, ,, length	10 ft. 3½ in.	10 ft. 5 in.
,, firebox, length outside ...	6 ft. 5 in.	6 ft. 4 in.
Heating surface, tubes	1,284 sq. ft.	1,130 sq. ft.
,, ,, firebox ...	119 sq. ft.	120 sq. ft.
,, ,, total ...	1,403 sq. ft.	1,250 sq. ft.
Grate area	20·6 sq. ft.	19 sq. ft.
Working pressure, lbs. per sq. in.	160	170
Weight in working order ...	45 tons 14 cwt.	46 tons 14 cwt.

The Caledonian engines are very plain examples of this essentially British type, and have few novel features; they are illustrated on p. 388.

The Great Northern engine is on more unusual lines, for the coupled wheels are larger than are commonly found in six all-coupled engines; this is owing to the design having been got out for handling either fast goods or passenger traffic. The wheels are 5ft. 8in., a diameter more often associated with the 2-6-0 type.

The cylinders are 18in. by 26in. inside the frames, and the

valve gear is of the Stephenson type. The boiler has a direct stayed round topped firebox of medium dimensions, the centre line of the boiler is 8ft. 0$\frac{5}{8}$in. above the rail.

As regards tank engines there has been rather more progress made than in other types, and we have previously instanced some of the designs. There are two others which have not yet been described in these columns. Both designs were brought out at the latter end of last year, but the bulk of the engines have been put into service during the current year. The first consists of a series of 0-4-4 tanks, a class that has of late years fallen rather into disrepute, but one which is capable of excellent work, especially on such a line as the North Staffordshire R., for which they have been built. We believe we are correct in saying that the largest run is from Stoke to Manchester, and some of these trains are being worked by the new engines. The cylinders (inside the frames) are 18$\frac{5}{8}$in. by 26in., and have their valves between them actuated by direct Stephenson gear. The boiler has a total heating surface of 1,120 sq. ft., of which the tube surface is 1,101·7 sq. ft., The grate area is 17·8 sq. ft. The fire-box is round topped, the crown of the copper box being stayed by roof bars or girders. The coupled wheels are 5ft. 8in., and the bogie wheels 3ft. 7in. diam. The rigid wheelbase is 8ft., the total base 20ft. The side and back water tanks have a capacity of 1,300 gallons. In working order the weight is 56 tons, of which the adhesion is 34 tons 15 cwts.

The other class of engines referred to are a novelty in regard to wheel arrangements for English tank engines, having a four-wheeled leading bogie and six-coupled wheels. These engines are working the trains of the Yorkshire Coast line of the North Eastern R. Their cylinders are inside the frames 18in. by 26in. The valves are of the piston type, placed below the cylinders and are actuated by Stephenson gear; the leading coupled axle drives. The wheels are 5ft. 1$\frac{1}{4}$in. diameter, the rigid wheelbase is 12ft. 6in., the bogie has a wheelbase of 6ft. 6in. and wheels diameter. The water is carried in large side tanks only, with a capacity of 1,500 gallons.

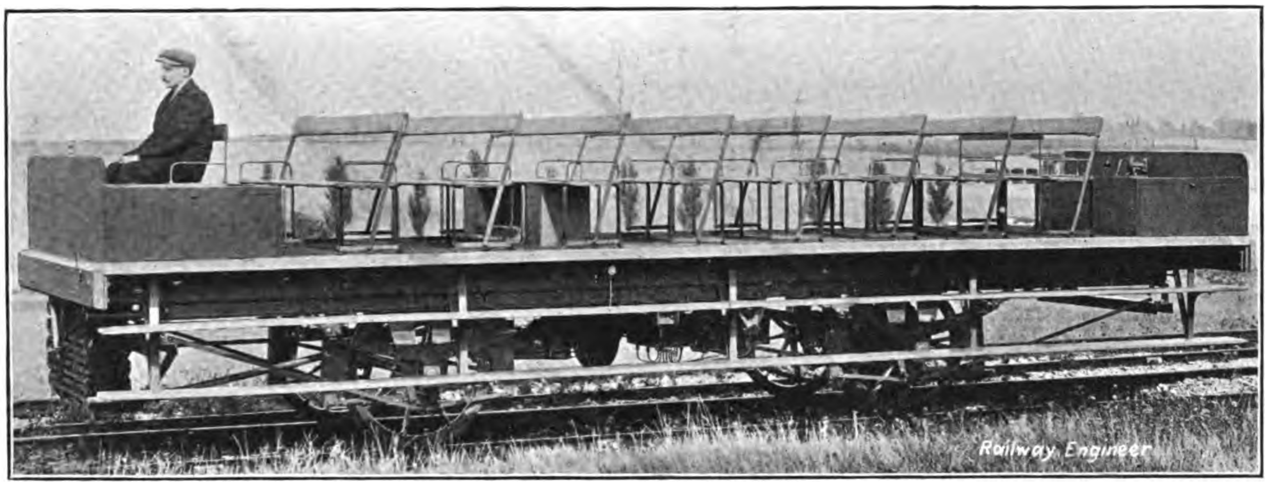
The boiler has a total heating surface of 1,312 sq. ft., the fire-box surface being 130 sq. ft., with a grate of 23 sq. ft.; the outside length of the fire-box is 8ft. 2in.; the copper box is stayed to the round topped shell by direct stays; the working pressure is 170lbs. In full working order the weight is 69 tons, of which 52 tons are on the coupled wheels.

Thornycroft's Motor Railway Car.

THE motor railway car built by Messrs. John I. Thornycroft and Co. at their Basingstoke Works for the Paknam R., Siam, will interest railway engineers, as it has many features which render it suitable for passenger or goods traffic.

It will be seen from the annexed illustration that the passenger accommodation is of the simplest character, as the car will be almost exclusively employed for carrying natives of the poorer class. It could, of course, be differently arranged as required.

The car is constructed to run on rails of 5ft. 6in. gauge, though the alteration to suit any other gauge would not be



very considerable. It is arranged to carry 40 persons, and is capable of ascending gradients of 1 in 40 or rounding curves of 2$\frac{1}{2}$ chains.

The fuel may be either petroleum (kerosene)—which is readily obtainable in all parts of the world—or petrol spirit, as desired, the efficiency of the engine being practically the same on either fuel. Sufficient fuel is carried for a total run of about 300 miles without replenishment.

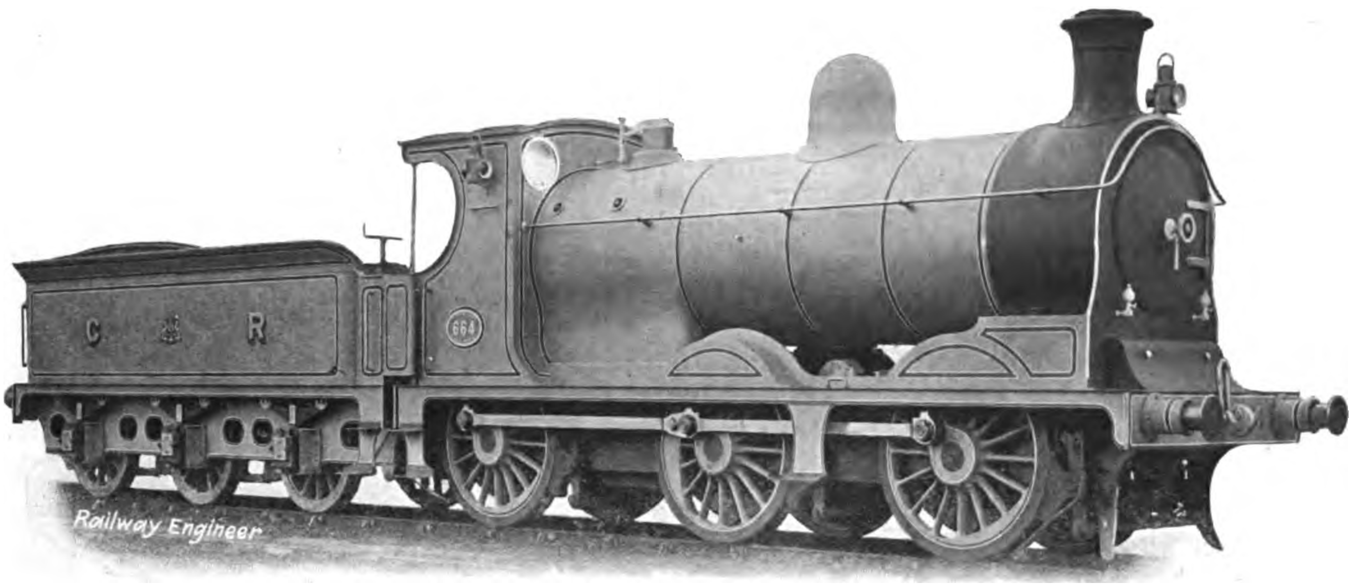
The four-cylinder engine fitted is of the standard Thornycroft type, developing 30-B.H.P. on paraffin. The crank shaft, cam shaft and gear wheels all run in oil-tight casings, while the valves are mechanically operated. The cooling of the engine is amply effected by means of a radiator of the tank type, with vertical gilled tubes.

The clutch is of the metal-to-metal type, and acts very satisfactorily. The transmission gear is arranged to give two speeds in either direction—the first up to about 18 miles per hour, and the second about 40 miles per hour, the maximum in each case being on the level. The final drive is by means of chain to one of the axles, and the whole of this gearing is enclosed in an oil-tight casing. The axle-boxes have Pennsylvania axle-box bearings, and have suitable means of lubrication.

Changing speed and reversing is controlled by single levers working in a "gate," one at each end of the car, so that the driver always faces forward and has an uninterrupted view.

The brakes are so arranged that the driver has control of a foot brake operating on the countershaft, and a hand brake operating on the leading wheel tyres, while the conductor has control of an independent hand brake acting on the trailing wheels.

On the trials, which took place on the L. and South-Western R. near Basingstoke, the car carried a load equal to 40 passengers, and negotiated an up-gradient of 1 in 40, with a 9-chain curve, at 15 miles per hour.



Six-Coupled Goods Engines (652 class), Caledonian Railway.

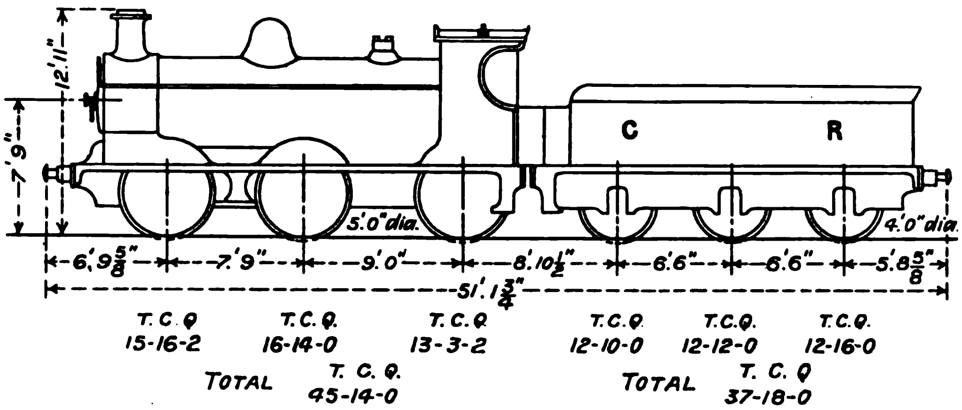
The annexed illustrations show the latest type of 6-coupled goods engine, designed by Mr. J. F. McIntosh, locomotive engineer of the Caledonian R., and of which a number are being built at the Company's works at St. Rollox, Glasgow.

The cylinders, 18½in. by 26in., are inside the frames and work on to the middle axle. The slide valves are between the cylinders, and are operated by Stephenson gear. The crank-axle is built up and has main journals 8½in. diam. by 7½in. long, and journals for the connecting rod 8½in. diam. by 4in. long. The leading and trailing axles have journals 8in. diam. by 7½in. long. The boiler tubes are of mild steel, and are galvanised. The safety valves are of the Ramsbottom pattern, 3in. diam., and are adjusted to blow off at a pressure of 160 lbs. per sq. inch. The crown of the copper fire box has girder stays.

The engines are equipped with steam brake and also ejectors and "through" vacuum brake pipes, thus enabling them to be used for working express goods trains.

A special feature of these engines is a new spark arrestor which bids fair to at last solve the difficult spark problem by diminishing live-coal throwing while keeping the dead cinders in such a position in the smokebox as to remain entirely clear of the bottom rows of boiler tubes. This effective and extremely simple appliance is the invention of Mr. McIntosh, and is the result of extended study and experiment in this particular direction, and so satisfactory has been its behaviour in actual working under severe and varying conditions that arrangements have been made for fitting it to all new Caledonian engines. It consists of a V-shaped plate placed vertically in the smokebox with the apex towards the tube plate. It is arranged to swing to either side of the blast pipe so that the tubes may be cleaned.

The principal dimensions are as follows:—



Cylinders: Diameter, 18½in. by 26in. stroke.

Wheels: Diam. on tread, 5ft. 0in.

Boiler: Height of centre from rail, 7ft. 9in.; barrel, 4ft. 3½in. diam. by 10ft. 3½in. long; thickness of barrel plates, $\frac{7}{16}$in.

Firebox shell, 6ft. 5in. long by 4ft. 0½in. wide at bottom; depth from centre at front 5ft. 6in. and 5ft. 0in. at back.

Thickness of covering plate, ⅝in.

Tubes: Number, 275; external diameter, 1¾in.; length between tube plates, 10ft. 7in.

Height of chimney above rail, 12ft. 11in.

Heating surface: Firebox, 119 sq. ft.; tubes, 1,284 sq. ft.; total, 1,403 sq. ft.

Grate area, 20·63 sq. ft.

Tractive force, 17,800 lbs.

Working pressure, 160 lbs. per sq. inch.

Weight of engine in working order, 45 tons 14 cwts.

Tender: Capacity of tanks, 3,000 gallons; fuel space, 4½ tons; wheels, 4ft. 0in. diam.; weight of tender, full, 37 tons 18 cwts.; weight of engine and tender in working order, 83 tons 12 cwts.; length of engine and tender over buffers, 51ft. 1¾in.

Roofs.—XII.*

Plate Girders.

Although plate girders are very frequently used, yet the theory of their design is by no means a simple one. Certainly it is comparatively easy to design plate girders in which certain rule of thumb methods are accepted, such as the flange area being designed to resist the bending moments and the web being assumed to take the shear, the whole section of each flange and each web being considered as resisting these respective stresses, and this as uniformly distributed over the metal in each part.

How the different parts do actually fulfil these functions is however by no means yet known, and especially in the case of the web a considerable uncertainty exists, particularly as regards the thickness, the stiffening and the actual distribution of the crippling or buckling stresses.

The first thing required in the design of a girder or roof truss is of course the approximation of the weight of the structure itself, to which may be easily added the loads due to the purlins and roof covering. As regards the weight of the plate girder Thomson (*Typical Steel Railway Bridges*) gives the following formula for a 60 ft. span deck plate girder bridge (two girders under one track of railway):

$$w = 10l + 100$$

where w is the weight of metal per foot of length, and l the length of the span in feet.

It is, however, obvious that for heavier loads the factor 10 given in the formula would have to be increased, whilst for lighter loads the same factor might have to be decreased, since it is plain that for the same length of span no formula can be used in which the anticipated loads do not form part of the consideration.

It is well for the designer of girder work to prepare for his own use a series of tables of weights of girders in which the span and the loads are included, of as many examples of actual girder work of known weights as he can find accessible, and by this means lay by a store of information that will afterwards be found of invaluable use.

Unwin gives the following formula for girders constructed of plate webs or lattice bars :—

$$P = wlr \div (cs - lr)$$

Where P = the weight of the girder
w = the total equivalent distributed load
l = the effective span
r = ratio of span to effective depth
c = a constant, usually 1,400 to 1,500 for small bridges, and from 1,500 to 1,800 for larger bridges
s = the intensity of working stress per square inch,

and to find the value of the constant c from girders of known weight

$$c = 4\,al \div P$$

Where a = the mean gross area of both booms or flanges in square inches

Stoney gives :—

$$G = wl^2 \div 12fd \quad \ldots \quad \ldots \quad \ldots \quad (1)$$

Where w = total distributed load in tons, including weight of girders
l = length in feet
d = depth in feet
f = working stress in tons per *square foot* of gross section
G = weight of main girder and end pillars in tons;

then if P = load on the girder in tons
$w = P + G$

and substituting this in (1) and reducing, we get

$$G = P\,l^2 \div (12fd - l^2) \quad \ldots \quad \ldots \quad (2)$$

which gives the weight of the girder when the distributed load on it is known.

As to the exact depth that should be taken in the calculation of the girder as the effective or virtual depth, it is not yet determined unanimously whether the depth should be taken as the distance centre to centre of the flange areas, or whether it should be taken as between the centres of the rows of rivets attaching the flange to the web of the girder, or whether the effective depth should be assumed to be that back to back of the angles connecting the flange to the web plates. Perhaps it is the best plan to take the latter in the preliminary computation of the stresses, and unless the angles are of very large section proportionately to the flange plates, the effective depth so assured will be somewhat less than the depth centre to centre of the flange areas, and so will err on the safe side.

The effective depth of a plate girder of any considerable size will be affected by the disposition of the flange plates, since at the centre of the span there may be three or four plates, whilst at the ends near the abutments there will probably be only one plate, and the depth centre to centre of the flange areas will therefore not be the same in the two positions.

As regards the hog backed girder where the depth is appreciably less at the abutments than at the centre of the span, it is obvious that corrections as regards the vertical depth will have to be made to meet the reduction in the depth.

In the case where the solid web of the plate girder is replaced by a series of lattice bars it appears almost obvious that the effective depth of the girder should be taken as between the centres of the clusters of rivets at the top and bottom of the lattice bars, though why this should be taken in the case of the open web girder and not in the case of the solid web girder does not seem to be by any means so clear. Perhaps it may be more satisfactory to decide the matter by referring to the design of the end attachments of the diagonal bars. If the centre lines of the rivet attachments are designed to meet in the centre of the riveting to the angle iron, then we may take the depth as being between such centres, but if on the other hand the centre lines of the diagonal bars of the web members meet in the centre line of the flange area then we may assume the vertical distance between the centres of the flange areas to be the virtual depth. At the present state of knowledge in this matter it is not by any means clear however that this is incapable of doubt, and the question must be left to the individual caprice of the designer.

It is the practice in America to take one-eighth of the web

c

* The previous articles of this series appeared in the *Railway Engineer* as follows :—I., May, 1907; II., July, 1907; III., September, 1907; IV., October, 1907: V., December, 1907; VI., February, 1908; VII., April, 1908; VIII., June, 1908; IX., September, 1908; X., October, 1908.; XI., November, 1908.

plate in a solid web girder as acting with the flange as resisting tension or compression stresses, but this is not by any means the practice adopted in this country. Why this arbitrary fraction of one-eighth should be taken and not a greater or less fraction of the web depth, is not quite clear.

When the centre of gravity of the flange area is taken as the effective depth of the girder, and when the lengths of the plates in the flanges are cut short to suit the bending moment diagram, the correct thing is to take the centre of gravity of the flanges and the effective depth at the different points along the length of the girder wherever there is such an alteration in the flange area, but it is very questionable whether this is not a refinement that is unnecessary in most cases.

In some American specifications it is laid down that the effective depth of a plate girder is to be considered as the vertical distance between the centres of gravity of the flange areas, with the provision that if this is greater than the distance back to back of the angles, then the latter dimension is to be taken as the depth.

It may be stated here that the strength of a girder is very frequently and perhaps more accurately found by means of the moment of inertia, or I, and the outer fibre stress, or f, both of which are involved in the equation

$$M = fI \div y$$

M being the resistance to bending and y the distance from the neutral axis to the outer fibre, f being the greatest permitted intensity of stress in the extreme fibre.

Sometimes also instead of taking y into account as the distance of the outer fibre, a reduction is made in that y is taken to the centre of gravity of the flange area, and the stress in this case is therefore the average and not the extreme stress.

In most cases of plate girders it is required that the bending moments or chord stresses shall be assumed to be resisted by the flanges only, whilst the shearing stresses shall be understood to be taken entirely by the web of the girder. This is of course a purely arbitrary assumption when we consider that a portion of the web plate is firmly riveted to the flange and therefore forms a part of it, whilst on the other hand for the same reason that the flange is riveted to the web and forms part of it, some amount of the shear both in the horizontal and the vertical sense may very well be taken by the angles and plates of the flange.

The rivets connecting the web plate of the girder to the flanges have to transfer the horizontal shearing stresses from the web to the flange, or in other words, the increment of the flange stress between any two rivets in the length of the girder. In the case of a girder where the load rests upon the top flange, the rivets connecting this flange to the web have, in addition, to distribute the load at each point to the web, whilst in the case of the loading being on the bottom flange the rivets have in the same way to transfer the load from the flange to the web in like manner.

Generally the riveting is required to be strong enough to take this longitudinal shear when it is assumed to be equal to the vertical shear divided by the distance centre to centre of the flange areas, the dimensions to be taken in inches or in feet, as the case may be. The vertical shear at any point of the span is of course the end shear less the amount of the load between the section in questioh and the bearing where the end shear occurs.

In the case of a load from cross girders or placed on the girders at certain distances or panels, the required pitch of the flange rivets will be found to increase gradually from the ends towards the centre of the span, and therefore also to increase between each of the panel points.

The rivet pitch is usually determined at the centre of the panel length, and although this will give too great a distance between the rivets at the abutment end of the panel and too small a distance between the rivets at the other end of the panel, yet the total number of rivets in the panel will be correct.

As regards the riveting in the centre of the girder where the horizontal shear in the web is at a minimum, of course the pitch of the rivets could be indefinitely large, but for constructional purposes it is not desirable to pitch the rivets at a greater distance than four inches, and also for the same constructional reasons both flanges are generally arranged the same way as regards the drilling for the rivets.

It would be desirable for shop purposes to keep this pitch of riveting uniform throughout the girder at all parts, but where this is not applicable in the case of heavy shearing or bearing stresses the requirements of riveting can be met by either increasing the diameter of the rivet or decreasing the pitch. In some cases, especially in shallow girders, it will be necessary both to make the pitch smaller, and at the same time to increase the diameter of the rivets.

The pitch of the rivets between the web and the flange angles is usually determined in the following manner:—

Maximum shear in tons ÷ depth of web in feet = horizontal shear in tons per foot, say 13 tons,

and if it be assumed that the safe shearing stress on mild steel rivets in single shear is five tons and in double shear seven and a half tons per square inch, and as a $\frac{7}{8}$in. rivet has a cross sectional area of 0·6 square inch, then the safe stress on each rivet in the flange angles, which of course are in double shear, is $0{\cdot}6 \times 7{\cdot}5 = 4{\cdot}5$ tons, and dividing the horizontal shear of 13 tons per foot by 4·5 we have

$13 \div 4{\cdot}5 = 2{\cdot}88$, say 3 rivets per foot, or a pitch of four inches.

The rivet pitch may also be ascertained in another way; given as before that the maximum shear in tons divided by the web depth in feet gives 13 tons as the horizontal shear per foot run, and if it is required to space the rivets at four inches pitch or three to the foot, then divide the shear per foot by the number of rivets per foot, or $13 \div 3 = 4{\cdot}33$ tons shearing stress to be taken by each rivet, and assuming $7\frac{1}{2}$ tons as the safe stress on steel rivets in double shear then $4{\cdot}33 \div 7{\cdot}5 = 0{\cdot}578$ is the cross sectional area of the required rivet, or $\frac{7}{8}$in. diameter.

But not only is it necessary to consider the rivet area to resist shearing both horizontal in the flanges and in a vertical sense in the web and the stiffeners, we must also take into account the bearing area of the rivets where they pass through the holes in the web. In the case just given we have 13 tons as the horizontal shear per foot run, and if it be assumed that the safe bearing area is 10 tons per square inch then

13 tons shear ÷ 10 tons per square inch = 1·3 square inches bearing area is required.

It has been previously found requisite to provide three rivets of $\frac{7}{8}$in. diameter in the foot of length, and if the thickness of the web plate is assumed to be $\frac{1}{2}$in., then we have

for the bearing area $\frac{7}{8}$in. × $\frac{1}{2}$ in. = 0·4375. In the foot of length there is required 1·3 square inches of bearing area, then 13 ÷ 0·4375 = 2·97, or say three rivets in the foot length, which gives the required number of rivets as before.

This may of course be worked out in another way. Assuming that three rivets per foot, each of $\frac{7}{8}$in. diameter, are required to transmit the stress, and that it is required to ascertain the thickness of web plate that will take the bearing of the rivets upon it safely at 10 tons per square inch. In this case

13 tons stress ÷ 3 rivets each $\frac{7}{8}$in. diam. = 4·95 sq. ins. for each ton of stress. Dividing again,

4·95 sq. ins. ÷ 10 tons stress per sq. in. = 0·495 in. as the required thickness of the web plate.

So much for the function of the web as regards the riveting attachment to the flanges. The next consideration is that of the crippling or buckling strength of the web plate, since it is obvious that if a flat, thin vertical plate fails under compression applied edgeways to the plate, it must be in the way of buckling it. It is of course well known that there is a tension in the web plate downwards from the ends towards the centre of the span, and compression downwards from the upper central portion of the girder down towards the bearings, but as to the precise function of each kind of stress as regards the effect upon the web plate there is very considerable uncertainty.

It is, however, known that given a girder with a thin web without stiffeners the tendency is to buckle the web along or near to the neutral axis, whilst if stiffeners are added at points along the girder between the flanges, then the tendency under failure is for the buckling to be articulated at the top and bottom of the stiffeners, forming diagonal lines as first stated. Of course there have been several formulas devised in order that this buckling strength may be estimated, with more or less accuracy, and the required thickness of metal in the web found to make sure against failure.

The Rankine-Gordon formula for compression as a column, where P = buckling stress, s = area of cross section, F = ultimate resistance to crushing of a short specimen, L = length of column, R = least radius of gyration; is

$$P \div S = F \div \{1 + (L^2 \div 36{,}000\ R^2)\}$$

and this may be simplified for a rectangular section, such as a web plate strip, to

$$P \div S = F \div \{1 + (L^2 \div 3{,}000\ D^2)\}$$

in this case D being the least diameter.

But the obvious difficulty in fixing upon the major width of the supposed column, and the knowledge that there are a very large number of old and new plate webs now doing good work that should have failed long ago according to the formula, places the theory out of court.

In "Engineering," of February 12th, 1902, Mr. Gribble suggests an adaptation of this formula as follows:—

For iron webs,

$$P \div S = 4 \div \{1 + (L^2 \div 10{,}000\ D^2)\}$$

and for steel webs 5·5 instead of 4 as the numerator at the right hand. In this case P = shear, S = vertical cross section, L = least distance, vertical or horizontal, between the supports of the web, D = the thickness of the plate.

Theodore Cooper gives his formula for web strength:

$$P \div S = 12{,}000\text{lbs.} \div \{1 + (L^2 \div 3{,}000\ D^2)\}$$

whilst Du Bois amends the numerator at the right hand to 10,000lbs., and in both cases an allowance for impact is to be made. This allowance is to be in the form of an additional percentage of load under the formula

$$40 - (2 \div 5)\ \text{span}.$$

In this case L is the length of the columns or strip of web, usually assumed to be the vertical distance between the web riveting of the top and bottom flange angles. This, however, does not seem to be correct, since if the web fails by crippling in a diagonal direction the length should be that of a line in the web at 45° with the vertical depth, and not a vertical line, as usually assumed.

Fitzmaurice, in his book on "Plate Girders," gives $3\frac{1}{2}$ tons per square inch as the safe stress in shear on the webs of wrought iron plate girders, but he does not give any indication how this figure is obtained.

Mr. Waddell states that for mild steel webs the safe stress per square inch, in which provision for impact is included, should not exceed 2·23 tons, and also suggests as a percentage formula for impact

$$40{,}000 \div 500 + \text{span in feet},$$

which is equivalent to 67 per cent. for a span of 100 ft.

Vertical stiffeners are to be placed at a distance along the girder not exceeding the depth of the girder, but this seems unsatisfactory in that if this is the maximum distance apart at the centre of the span, then the rule does not provide for the closer spacing of the stiffeners as the end bearings are reached.

(To be Continued).

Single-Phase Electric Traction on Railways.—III.*

THE electric locomotives for the New Haven RR. had to comply with unusual conditions, viz.:—They had to haul the local express trains, which weigh about 200 American tons (2,000 lbs.) and which stop about every two miles, at an average speed of 26 miles per hour and a maximum speed of 45 miles per hour; expresses of the same weight at 65 to 70 miles an hour; expresses of 250 tons at a speed of 60 miles per hour; and heavier trains at a correspondingly lower speed, but if such heavier trains had to be hauled at a higher speed two or more locomotives were to be coupled together and operated on the multiple-unit system. These locomotives were designed by the N.Y.N.H. and H.RR. Co., the Westinghouse Electric and Manufacturing Co., and the Baldwin Locomotive Co. The latter firm built the mechanical parts, which are entirely of steel.

The engines are 36 ft. 4 ins. over the buffers, weigh approximately 90 tons, and are mounted on two trucks each with four 62in. driving wheels.

The hollow shaft of the armature is constructed in two halves which are alike, and are each provided with an end disc, from which project seven hollow pins. The armature and quills are mounted on the locomotive axle. The armature bearings are carried by the split housings at each end of the armature, and which are rigidly clamped to the outer field frame of the motor. The field structure is thus mechanically connected by two bearings to the armature structure, and this insures that the armature will remain at all times concentric to the field poles.

Through the armature quill passes the axle of the loco-

*No. I. appeared in August issue and No. II. in October.

motive, and on each end of the latter is mounted a driving wheel 62ins. diameter. Seven circular pockets are formed in the hub, and these contain helical springs for assisting in carrying the weight of the motor and for transmitting the torque from the armature. Into each of these pockets there projects one of the hollow pins above-mentioned, and each pin is surrounded by a spring placed between the outer circumference of the pin and the inner circumference of the pocket. These springs are of an unusual form, and are capable of sustaining the whole weight of the motor, but their normal use is for transmitting the torque to the drivers. In the hollow space of the pins is placed another spring, and this is for receiving the end thrust of the motor against the drivers.

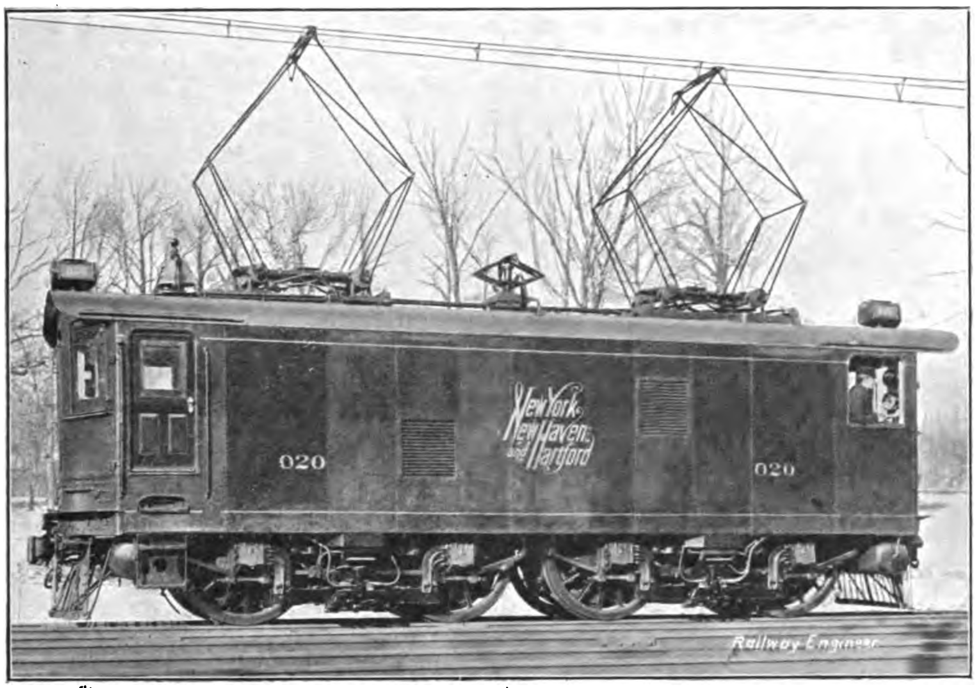


Fig. 18.

A steel frame is provided entirely distinct from the truck and pivoted from the journal boxes of each locomotive axle, and from this frame the weight of the motor is carried by springs on which rest lugs of the field structure. The result of this is that the swinging of the locomotive has no effect on the motor, and only a cushioned blow is given to the rails by the motor. In fact the whole motor is spring borne.

As the New Haven trains runs over the New York Central lines into New York, and as these lines are equipped with third-rail direct-current and not overhead construction with alternating current, the locomotives were built so as to be available for either system. Special features have, therefore, been necessary in the motive equipment.

The active armature winding consists of several coils per slot with one turn per coil. The coils are made of form wound strap, and are inserted in the slots from the top. The field winding is of the compensated type, arranged in two circuits—the main field coils placed around projecting poles on the field core and producing the active field flux, and the compensating field coils placed in slots in the projecting pole faces and serving for opposing the armature magnetomotive force and thus for neutralising the reactance of the armature.

The compensating field coils are, at all times, electrically in series in the armature circuit whether the machine be operated by direct-current or alternating current. Two motors are operated as one unit, and the separate field circuits of these motors are placed in series or in parallel as desired according to the current used. For direct-current work the two motor units are connected in series at starting and in parallel at full speed, while for alternating current work the two units are operated separately from the secondaries of the step-down transformers at variable voltage so that they are practically joined in parallel at all times.

During alternating current operations each motor unit is fed at variable voltage from the secondary of a step-down transformer, there being two separate and distinct transformers on each locomotive. The object of this arrangement was two-fold. First, to more conveniently dispose of the weight of the transformers, and, second, to secure increased reliability. The master controller is the same for either system. Each switch used in the motor circuits is of the Westinghouse "unit" type, operated by air under 80lbs. pressure, and controlled by an electro-magnet which receives current from a 20 volt storage battery.

The high-potential circuits pass directly from the overhead trolley wires through the manually operated oil switch to one terminal of the primary of each of the step-down transformers, the other terminals of which are effectively grounded to the locomotive frame.

The motor circuits pass either from direct-current trolley,

Fig. 19.

third-rail shoe, or the taps on the secondaries of the transformers to the unit switches and through the motors to the ground.

The locomotive may be controlled from either end by means of a master-controller. There are two pantagraph

bow trolleys for collecting the current from the 11,000 volt overhead system. These are seen up in fig. 18 and down in fig. 19. The upward pressure against the wire is supplied by springs in the base of the pantagraph equipment. Compressed air is admitted to a cylinder when it is desired to lower the collector.

In the centre between the two pantagraphs will be seen a lower one, for direct current, and between each pair of driving wheels there is a pair of third-rail collecting shoes. These are for use on the New York Central RR., the small pantagraph being for those places where, owing to complicated permanent way, the third-rail cannot be fixed, and current has to be obtained from overhead equipment. There are four shoes on each side or eight in all. When the pantagraphs are raised for alternating current the contact shoes are lifted out of the way, as seen in fig. 18.

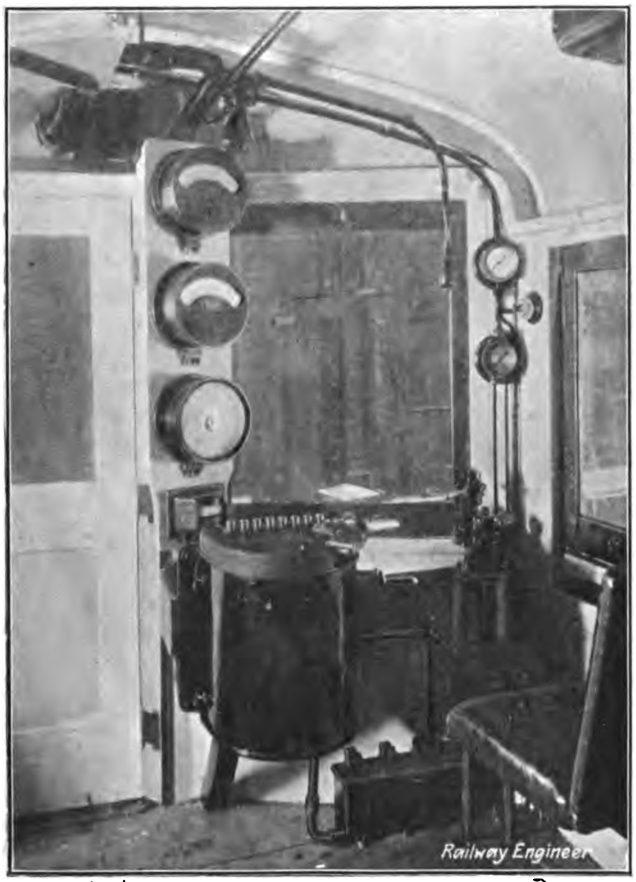


Fig. 20.

Fig. 20 is a view of the interior of the motorman's cab, on the right is the air-brake with the gauges above, on the left is the controller, and above it are a direct-current ammeter, an alternating current ammeter, a speed indicator and a pyrometer for indicating the temperature of the propelling motors, and which is to guard against the air-ducts getting clogged. The operating handle is on the right on the top of the controller, and lower down is the reverse lever which is attached to the operating handle, and interlocks it so that the reverse lever must have made all the control circuits dead before it can be withdrawn to allow for the operating handle to be taken to the controller at the other end of the locomotive. The row of eight knobs complete circuits from the storage battery to magnets opening or closing air-valves, whereby such duties are performed as raising and lowering the pantagraphs, third-rail shoes, operating the sanders and ringing the bell. Three pedals are seen on the floor. These are for operating the two sets of sanders (front and back) or ringing the bell by pressure of the foot.

Mr. McHenry, the vice-president of the New York, New Haven and Hartford RR., who supplied us with the foregoing information, says that there are now 135 trains running daily between New York and Stamford, and giving every satisfaction. There has been introduced a decidedly novel feature in the overhead construction, which is a second parallel steel wire under the copper trolley wire which is flexibly supported by clips, 10ft. apart, to the upper copper wire, and the two wires are about 2ins. apart. The points of suspension are intermediate between the trolley hangers or triangles, and the securing clips are designed to engage with the grooves of the upper wire in such a manner as to prevent rotation about its axis. The advantages of this innovation consist in relieving the copper wire from all wear, in avoiding the rigid points of support which were found to cause considerable trouble at high speeds, and in permitting tension adjustments to the anchor bridges, which are spaced two miles apart. It also obviates any difficulties occasioned by the greater rate of temperature expansion of copper as compared with steel, and as the steel wire has greater tensile strength and elasticity the extreme temperature ranges of summer and winter are all taken up safely within the elastic limit of the metal.

The results have been satisfactory in the highest degree, and the cost of maintenance is expected to be less, as steel is not only much cheaper than copper, but lighter, stiffer and harder—all very desirable qualities in resisting wear and bending.

New Zealand Government Railways, 1907-8.

The Minister for Railways, in his statement for the year ending 31st March, 1908, announced that the result of the year's operations has been satisfactory. The revenue maintained that buoyancy that has characterised it for the past 13 years, and, notwithstanding the liberality of the forecast made at the close of the previous financial year, the actual earnings exceeded the estimate then given by no less than £211,938. The results may be summarised thus:—

	1908.	1907.
Total earnings	£2,761,938	£2,624,600
Total expenditure	£1,949,759	£1,812,482
Net profit on working ...	£812,179	£812,118

The net profit is equal to a return of 3.33 per cent. on the capital invested in the open lines, and 3.04 per cent. on the total capital, £26,735,140, invested in opened and unopened lines.

The mileage of line open for traffic on the 31st March, 1908, was 2,471 miles as against 2,456 for the previous year. The average number of miles operated during the year was 2,469.

The number of train-miles run during the year was 7,051,274, being an increase of 295,820, which cost over £81,000.

The total number of ordinary passengers carried was 9,756,716, an increase of 155,930 over the previous year.

The coaching and goods traffic show large increases under each of the respective heads that the traffic is grouped, sheep, wool, and grain excepted. In coaching, the increases have been—parcels, 7,636; horses, 653; carriages, 389; dogs, 5,685; and in live-stock and goods traffic—cattle, 17,720 head; pigs, 10,765; chaff, lime, etc., 1,451 tons; firewood, 918 tons; timber, 49,057 tons; merchandise, 45,248 tons; minerals, 184,467 tons. The decrease in the wool traffic is 7,568 tons, grain 31,138 tons, and sheep 67,901 head. The net increase in the gross tonnage was 246,000 tons.

The decrease in sheep traffic is due entirely to the heavy movement of sheep that took place during the previous year owing to drought. Although, therefore, the sheep traffic for the year under review compared unfavourably with that for 1907, it is nevertheless

greater by some 700,000 head than the traffic of any other year when normal conditions have prevailed.

The average number of men employed during the year was 12,338, against 10,858 the previous year, an increase of 1,480.

The sum of £5,418 has been paid as compensation during the year to members retired from the service and to relations of members deceased. This sum includes £5,364 paid under the Workers' Compensation for Accidents Act.

The railway workshops of the Dominion have been kept going at high pressure on the construction of new rolling-stock for increasing the equipment of the existing lines and providing for the requirements of new lines to be opened in the near future. The new stock actually completed and turned out of the shops during the year consists of 3 tender engines four-cylinder balanced compound type, 1 single-expansion tender engine, and 6 heavy tank-engines; three 60 ft. suburban cars, one 60 ft. motor-train car, and forty-nine 47½ ft. cars; 18 brake-vans, 855 goods-wagons, and 2,889 new tarpaulins. The carrying capacity of the wagon-stock was, moreover, increased by 9,670 tons, which is equivalent to a further addition of 1,612 ordinary 6-ton trucks. 2,095 new steel axles were fitted to carriages, vans, and wagons in substitution of old iron axles; greater strength and increased carrying capacity have thereby been secured. The new stock is all fitted with the Westinghouse brake and steel axles.

Passenger revenue shows an increase of £12,406; season tickets, £8,519; coaching traffic, £24,963; goods and live-stock, £83,642; miscellaneous and rents, £7,808. The receipts per train-mile amounted to 93.75*d*., as against 93.00*d*. for the previous year. The earnings of the Lake Wakatipu steamers amounted to £6,637, as against £6,159 last year.

The expenditure for the year, including £5,377 incurred in connection with the Lake Wakatipu steamers, absorbed 70.59 per cent. of the revenue, as against 69.06 per cent. for the previous year:—

	1907-8. £	1906-7. £	1907-8. %	1906-7. %
Traffic	534,634	494,942	19.40	18.90
Locomotive	733,403	657,893	26.62	25.13
Maintenance ...	638,560	613,890	23.18	23.45
Management ...	76,082	73,376	2.76	2.80
	1,982,679	1,840,101	71.96	70.28
Less credit recoveries	38,297	32,701	1.39	1.25
	1,944,382	1,807,400	70.57	69.03
Lake Wakatipu steamers	5,377	5,082	0.02	0.03
	£1,949,759	£1,812,482	70.59	69.06

Other particulars not given above are:—

	1907.	1908.
Capital cost of opened and unopened lines	£25,438,568	£26,735,140
Capital cost of open lines	£23,504,272	£24,365,647
Capital cost per mile of open lines ...	£9,570	£9,861
Earnings per average mile open... ...	£1,078	£1,114
Working expenses per average mile open	£744	£786
Net earnings per average mile open ...	£334	£328
Earnings per train mile	93.00*d*.	93.75*d*.
Working expenses per train mile ...	64.21*d*.	66.18*d*.
Net earnings per train mile	28.79*d*.	27.57*d*.
Passengers, ordinary	9,600,786	9,756,716
Season tickets	165,504	185,174
Goods tonnage	4,592,099	4,834,534
Live-stock tonnage	232,464	235,642
Train mileage	6,755,454	7,051,274
Locomotives	398	410
Passenger-cars	966	1,002
Wagons and brake-vans	14,605	15,475

A Railway Classification Act was submitted to and duly passed by Parliament during the last session. It embodies the allowances granted in November, 1905, to certain members of the railway service, and provides for improved pay to the staff generally.

Regulations under section 4 thereof relative to the payment of a minimum salary of £130 to married members of the service or to members of the service who are widowers with children dependent upon them, and also relative to the payment of a minimum salary of £100 to members who are 22 years of age or over, have been approved and are now being gazetted.

Arrangements have been made by which all railway employees who have been employed in the railway service continuously for a period of five years or over, but whose status has only been that of casual employee, will be placed upon the permanent staff.

Eighty-two Tyers' electric tablet train-signalling instruments were installed between Waihi-Paeroa, Masterton-Woodville, Oamaru-Pukeuri, and Mosgiel-Gore, embracing 160 miles of line. Extensions of the system between Marton and Mataroa, Woodville and Dannevirke, and Frankton and Taumarunui are in hand.

For train-signalling on the double lines between Auckland and Penrose, Wellington-Lower Hutt, Heathcote-Rolleston, Sykes' lock and block system is being installed.

Automatic tablet exchangers were installed at 19 stations during the year.

The electric tablet train-signalling system has been installed over a total of 848 miles, covering the sections—Henderson-Auckland, Onehunga-Morrinsville, Paeroa-Waihi, Longburn-New Plymouth, Te Aro-Woodville, Palmerston North-Woodville, Lyttelton-Heathcote, Rangiora-Rolleston, Pukeuri-Gore, Wingatui-Omakau, Bluff-Winton, Makarewa-Riverton, Westport-Granity, and Greymouth-Ngahere. The staff and ticket working is also in operation over 67 miles of line.

Permanent Way.—V.*

Sleepers.

The sleeper forms one of the three chief constituents of the permanent way—the other two being the ballast and the rail. The sleeper and ballast together give both rigidity to the rail and elasticity under the load of a moving train. As the ballast carries the sleeper, so the latter carries the rails and distributes the weight of the rail and its load over a larger area, so that the ballast is not crushed or unduly worn down, and at the same time acts as a tie—hence the American appellation—to keep the two rails parallel. The sleeper must therefore be of such a size as to counteract any disturbance caused by a moving train, and yet it must be of such a size and weight that it can be readily purchased in large quantities and conveniently handled.

The length of a sleeper is important. One that is too short would bend and give an outward inclination to the rails, while one that is too long would cause a contrary effect.

The quality of a sleeper is a leading factor. Not only must it be able to carry the load, but to withstand the climatic conditions, such as heat, cold and moisture, which may be extreme in some countries, also the ravages of such pests as white ants and any ill-effects of the particular ballast that may be used, and to enable it to do this more effectively it is often subjected to some process or treatment before it is put into the road.

The origin of the timber used varies in each country. Some few, as Russia, Austria, America and Australia, use only indigenous woods. British railways have Baltic wood (*Pinus sylvestris*—the true Scotch pine—also known as redwood, Dantzig, Riga or Swedish fir). There is, by the way, considerable confusion over the naming of soft woods. The names fir and pine, owing to their likeness to each other, are often used indiscriminately. Whereas fir is the genus *Abies*, sub-order *Abietineæ*, order *Coniferæ*, and pine is the genus *Pinus* of the same sub-order and order. On the Great Western R. a great deal of Australian timber has been laid.

In France indigenous oak and beech are used. The P. Lyons and M. R. and the Southern R. obtain their oak from Italy—also Baltic pine (*Pinus laricico*) and Landus Maritime pine (*Pinus pinaster*). In Belgium oak and fir are used, also beech to a limited extent. The sleepers on German railways are cut from native oak and pine, but beech is becoming popular there, and as, when creosoted, it gives good results it is likely to be more generally used, as a large proportion of German forests consist of beech timber, and as proper systems of afforestation are in vogue there Austrian railways have oak and beech. Russian use only indigenous

*No. 1 appeared in the August issue; II. in September; III. in October; and IV. in November, 1908.

wood, generally pine; oak and teak are used in Holland, and the indigenous common oak in Italy.

Of the railways in India on which wood sleepers are used, the Bombay, Baroda and Central India R, use creosoted Norwegian pine, the Rajputana-Malwa R. and the East Indian R. use deodar (*Cedrus deodara*) from the Himalayas, and which has an essential oil peculiar to it, preservative treatment prior to laying is unnecessary. Intense heat will evaporate this oil and then white ants attack the wood, so it is shielded from the sun by covering with ballast. On these railways sâl (*Shorea robusta*) is also used, from Nepal, and which is said to last 20 years without preservative. The Eastern Bengal R. have sâl and the North-Western R. deodar.

The Australian railways use the indigenous eucalyptus timber—iron bark (*Eucalyptus siderophlia*), jarrah (*E. marginata*) and Karri (*E. diversicolor*)—which do not require treating.

Of the South and Central American railways much of the Mexican Central R. is laid with a native oak, which grows along the rivers, but it only lasts a short time, owing to wear and tear in the road. There is also a native cedar that lasts eight years, and chigol, which lasts 20 and does not rot at all. Treated timber is now being tried on the Mexican Central R. On the Tehuantepec R. a hard Huayacan native wood is laid on curves and Californian redwood on straight lines, and neither is treated. Creosoted Texas long-leaf pine and Baltic pine are also favoured. In Trinidad the indigenous woods, balata (*Mimusops globosa*), black poui (*Tecoma serratifolia*) and black fiddle-wood are preferred, but as they are getting scarce American yellow pine and Baltic redwood—both creosoted—are being used. In Jamaica only indigenous fiddle-wood (untreated) has been used since 1900.

On the Buenos Ayres Western R. the indigenous *Quebracho Colorado* (untreated) is found to last better than Australian karri. It is very hard, stands pressure wonderfully and the supply is very liberal.

On the railways of the United States and Canada white oak is generally used. This wood does not rot quickly, but on account of its hardness it fails through decay more quickly than through wear. Other woods are preferred in the following order:—Cedar, Long-Leaf Pine, Chestnut, Hemlock and Tamarack.

As sap is more liquid in spring and summer trees should be felled during the winter months from November to March in order that the sap can be the more easily removed and replaced by a preservative.

The practice differs as to cutting the timber into sleepers as soon as it is felled or leaving it to season for a while first, but in any event only for a few months—not more than six is allowed. Oak is, however, an exception to this rule occasionally; *e.g.*, the Northern of France specify that oak must have been felled two years before being cut up, and the Western of France from two to three years.

Sleepers should be of a uniform thickness. Any changes in the thickness of sleepers in a track causes the deflection set up by a passing train to vary and lead to uneasy running. Whilst thin sleepers do not give a stable road and there is a want of stiffness, thick sleepers are hard to adjust and pack.

The standard for British railways is 5 ins. thick by 10 ins. wide. In France sleepers are 22 or 24 *cm.* (8.66 ins. or 9.45 ins.) wide and 14 or 15 *cm.* (5.51 ins. or 5.91 ins.) thick. In Belgian State R. 14 *cm.* (5.52 ins.) thick by 28 *cm.* (11 ins.) wide. In Germany the sleepers are 16 centimetres (6.31 ins.) thick, 26 *cm.* (9.25 ins.) wide and 2.5 metres (8 ft. 2½ ins.) long.

In India the standard gauge—5 ft. 6 ins.—lines have sleepers 10 ins. by 5 ins., and the metre gauge lines are 8 ins. by 4 ins. In Australia the general size for 3 ft. 6 ins. gauge lines is 9½ ins. by 4½ ins. In New South Wales it is 5 ins. thick by 10 ins. for standard gauge.

The sleepers of the railways of the United States and Canada have a general minimum width of 8 ins., but the larger and more enterprising companies have adopted a width of 9 ins. The average thickness is 7 ins., but some are only 6 ins. thick. In comparing this depth with British methods it must be remembered that the latter are square, but the former are half-round, and the dimension given is for the thickest end. The "recommended practice" of the American Railway Engineering and Maintenance of Way Association is that "except in pole-ties with rounded ends, or in half-round ties, "none shall be less than 8 ins. width of face, and in no tie "shall the thickness be less than 6 ins."

The standard length for sleepers for the 4 ft. 8½ ins. gauge railways in this country is 9 ft.; on French and Belgian railways 2 *m.* 600 or 2 *m.* 650 (8.52 ft. or 8.7 ft.); on 5 ft. 6 ins. gauge lines of the Bombay, Baroda and Central India R. 9ft.; on the East India R. and the Nizam's R. 9 ft. 6 ins.; and the Eastern Bengal R., Madras R. (on the east coast) and the North-Western R. 10 ft.; on the New South Wales and 4 ft. 8½ ins. gauge lines of Australia 10 ft.; and on the 3 ft. 6 ins. gauge 7 ft. In Demerara the sleepers are 9 ft. long for the 4 ft. 8½ ins. gauge and 8 ft. for 3 ft. 6 ins. gauge. At one time the latter were 6 ft. 6 ins. long, but as the land is alluvial the road bed is soft and longer sleepers were found to keep the line in better order. Most of the American and Canadian railways are laid with 8 ft. 6 ins. sleepers, but on a minority a length of 8 ft. is used.

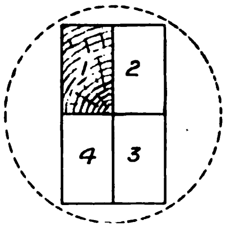


Fig. 26.

Fig. 27.

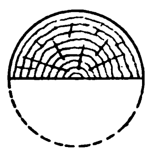


Fig. 28.

Fig. 29.

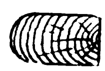


Fig. 30.

Figs. 26—30 illustrate the general shapes adopted for sleepers. Fig. 26 shows a tree cut up into four rectangular sleepers and known in America as "quarter ties." It is generally agreed that this is the best shape. One reason for this is that it resists mechanical action better. All British and other railways, except some of the Continental and American railways, use it entirely.

Fig. 27 is what is known in America as a "slab-tie," and may be either rectangular or half-round. Fig. 28 is an untrimmed "slab-tie." Fig. 29 is a "pole-tie." Fig. 30 is

a "half-tie." The difference between a "pole-tie" and a "half-tie" is that in the former the heart is in the top or bottom face and in the latter in a side face.

Many companies prefer adzed or axe-hewn to sawn sleepers. All British sleepers, and practically all Indian, are sawn.

In America, on the contrary, hewn sleepers are generally preferred, though they are not now used as much as they were. This is due to the greater scarcity of the small timber out of which the sleepers were hewn. It was the practice to only allow one sleeper to be made from a trunk. The objections to sawn sleepers are that the cut cannot always be parallel with the fibre and the surface is not so smooth, and therefore allows for moisture to gather.

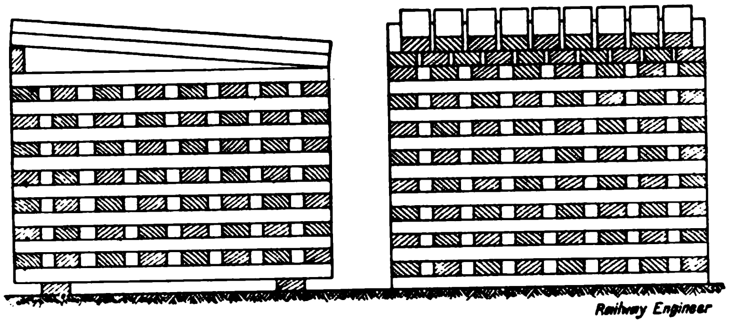


Fig. 31.

When cut up the sleepers should be stacked so as to allow air, light and warmth to circulate freely amongst them. The bottom layer should be off the ground on iron or stone supports. Failing these, hard creosoted wood should be used and this must be perfectly sound. It is most important that the ground on and near which the sleepers are stacked should be kept clean—free of pieces of bark, branches and leaves. The top layer of sleepers should be placed close together, with the ends on one side raised so as to act as a lean-to to throw off any rain or wet.

The inspection of sleepers by the railway company's representative is often made when stacked in the forest. Not only should those be rejected that show shakes, worm-holes, rot and hard knots, but any whose wood is changing colour, such as red doatiness appearing in the heartwood of beech and oak and blue doatiness in the sapwood of pine and other resinous woods. Such indicate that germs are at work. Pickling may obviate all possible ill-effect, but this is doubtful.

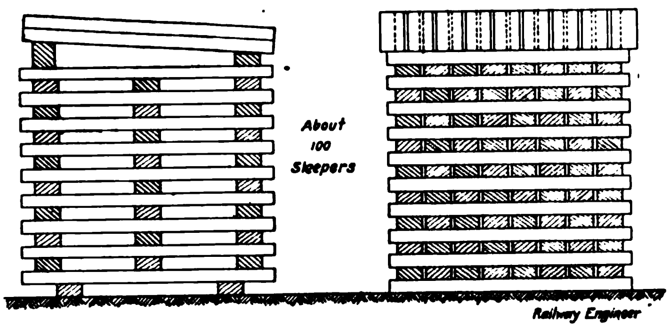


Fig. 32.

Opinions differ as to whether it be an advantage to transport sleepers by water. It is generally thought that this washes out the sap from the wood, so that, after being dried, it is the more readily impregnated when pickled. Some, however, consider that the water softens the wood.

On arrival at their destination the sleepers are again stacked in piles of from 80 to 120 sleepers until they become quite dry. It is a good plan to first stack them vertically, so that the water drains off quicker. Fig. 31 shows how untreated sleepers are piled on the L. and South-Western R., and fig. 32 the method of the Paris-Orleans R. of France. After being stacked for some months they are creosoted or treated with some kind of preservative.

As the subject of the preservation of sleepers was dealt with in the pages of *The Railway Engineer* under the heading of wooden sleepers as recently as May, 1906, July, 1906 and

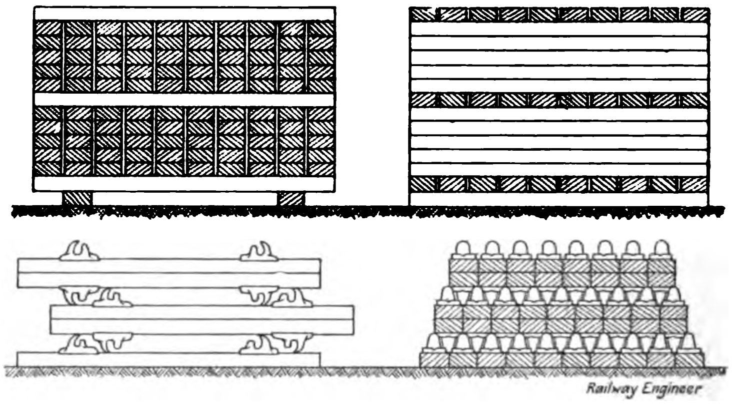


Fig. 33.

January, 1907, it is hardly necessary to say more now on that point.

After treatment they should be once more packed ready for delivery and again stacked when delivered. Fig. 33 illustrates how the L. and North-Western stack their creosoted unchaired and chaired sleepers. They should be covered with some sand or cinders on the top.

(*To be continued*).

The Simplon Route to Italy.—II.*

For nearly three years the Simplon tunnel has been in operation, in connection with the new approach-lines at the southern side, and with the old Brig-Lausanne line at the northern side. With the forced ventilation provided in the tunnel, the aeration of this longest and deepest subterranean passage in the world proved to be admirable from the first, though the traffic was worked exclusively by steam locomotives. The heat of the tunnel, due to the high temperature of the rock alone, does not appear to have been materially augmented by the locomotives. Nor were the smoke and gases from the locomotive fires sufficient to inconvenience the engine men in their duties, or to really disturb the most fastidious of passengers—who never become so very exacting as to the quality of the air which they breathe until they enter long tunnels. At such moments the windows and the ventilators are slammed up close and kept so until the vitiation of the air inside the carriage becomes intolerable, although a fast current of pure and fresh air is passing along the outside of the train. In the Simplon, with steam locomotives, it could be seen that the discomfort caused to passengers—especially to smokers, who smoke all the harder, when in tunnel, as an antidote to the "poisonous" air outside—was due to their absolute ignorance of the splendid ventilation of the tunnel. As a matter of fact, it was only for a few short minutes when entering the tunnel at the southern end—when the gradient is steepest—that the

*No. I. of this article appeared in March, 1906.

fumes from the engine fire were noticeable, while throughout the greater length of the tunnel the ventilation was far superior to that of short unventilated tunnels with steam traction, or of some underground railways with electric traction. The heat of the Simplon tunnel has nothing to do with the form of traction employed, although popular notion, accompanied by self-imposed semi-asphixiation has done much to show the contrary. Another very curious fact to be noted was that the passengers (Italians and Swiss) who closed themselves up hemetically-tight in the carriages —because they were aware that it was a steam locomotive on the train in front—really appeared to suffer from a temperature which, at the most, never reached that which English folk insist upon as being only just "right" for an English summer. The crowning task, rendered imperative by the boring of the Simplon, is the construction of the tunnel under the Loetschberg, in the Bernese Alps, and of the new lines in connection join Brig direct with Bern, and thence, by the French Eastern Railways, with the northern riviera of France—Dunkirk, Calais, Boulogne, etc., so establishing a more rapid connection between England and the Mediterranean and Adriatic littorals. In view of the wholly different system of work in the Loetschberg it may be interesting to record in a succinct and chronological manner all the principal events of the construction of the more fortunate Simplon Tunnel.

1898.

Aug. 1.—Excavating the alignment gallery at north end, Brig, commenced. *Aug.* 10.—Operations for excavating main gallery, north end, commenced.

Aug. 16.—Alignment gallery (No. 2) at Iselle commenced

Sept. 24.—Main gallery at Iselle (south end) commenced.

Oct. 8.—North end, curved main gallery met straight alignment gallery.

Oct. 11.—South end, main gallery met alignment gallery. North end, much water from 85*m.* to 179*m.*

Nov. 21.—Hand excavation ceased at north end, and machine boring begun, at 60*m.* Nature of rock: Argillaceous crystalline schists with quartz pebbles (mud at 318*m.*).

Dec. 21.—Machine boring begun at south end.

Dec. 31.—Total advance, north end, 333 metres (explosive, dynamite), and at south end 76 metres (explosive, powder). Nature of rock: Antigorio gneiss.

1899.

Feb. 18.—Two Brandt rock borers started in No. 2 heading of north end.

Mar. 15.—Three new-type Brandt borers started in No. 2 heading.

Apl.—Liquified air tested as explosive, north end (rock as before described).

Aug.—Steam plant supplanted by water turbines at north end.

Nov. 15.—Collapse of portion of No. 1 transverse gallery at north end. Argillaceous schistic limestone becomes micaceous from kilom. 2 to kilom. 3.

Nov. 29.—Death of A. Brandt, manager at north end. Col. E. Locher succeeded him.

Dec. 31.—Total advance: 2,300*m.* from north end, and 1,566*m.* from south end. Rocks.—North end: Crystalline schists, dolamitic limestones, and anbydrite; south end: Antigorio gneiss.

1900.

Mar. 1.—North end. Miners carried to headings in trains.

Jun. 1.—North end. Natural ventilation by shafts superseded by temporary steam plant.

Jun. 25.—North end. All workers in tunnel carried by trains. Timbering necessary between klms. 3·33 and 3·75. Rock friable (silicious and grey micaceous limestone).

Jun. 3 South end. Power pipe line burst: recourse to steam plant.

Jul. 10.—South end. Temporary ventilating plant superseded by the permanent ventilating station.

Aug. 27.—South end. Mud in power pipe line (due to heavy rains) causes cessation of high pressure service to rock borers. South end. Timbering very generally necessary. Antigorio gneiss becomes softer and less compact, broken and mixed with schistic and micaceous veins.

Sept.—North end. Small springs more frequent. Rock seamed and broken.

Nov. 29.—South end. Power supply interrupted for a week by bursting of power main; steam used.

Dec—South end. The fissures in antigorio gneiss contain a pasty unctuous matter (kilom. 3·036 to 3·100).

Dec. 31.—Total advance: North end, 4,119*m.*; south end, 3,148*m.*

1901.

Feb.—Hydraulic power main from Diveria river burst at two points. For 23 days all services worked by the provisional steam plant.

Mar. 18.—North end. The definite ventilating plant commenced work.

Apl.—South end. Up to kilom. 3·820 water springs only aggregate 5 litres per second. A fissured black mica schist reached, between 3·891 and 3·893, with a heavy inburst of water of 160 litres per second, and up to beginning of July the rock was saturated.

Jun. 13 to 21.—Strike of masons and miners at south end, and at north end on June 24.

Jul. to Sept.—North end. Rock: mica-schist and gneiss of the Monte Leone—occasionally granatiferous (garnet-bearing).

Aug.—South end. Temperature of water at rock outlet is 18° and 19° C. At kilom. 4·325 the antigorio gneiss replaced by saccharoid and schistic limestones, and between the two on Sep. 30 there was water, 100 litres per second; temperature, 17° C.

Oct.—Work suspended. Endeavoured to advance by means of crown drifts.

Nov.—South end. Advance during month only 29 metres. Rock: Micaceous crystalline limestone (cipolin); after kilom. 4·420: decomposed micaceous schists (carbonate of lime, white mica and clay). Excavation alternately by machine and hand.

Dec.—South end. Monthly progress only 2 metres. Heavy pressure broke the strongest timberings. Total advance, 4,428 metres from south and 6,335 metres from north. Temperature of rock in headings, 39° C.; of spring water, 35 to 36° C.; and of air at heading face, 31° C.

1902.

Jan.—South end. Seven iron frames erected in place of wood to resist pressure. Length supported by these, after month's work, 2·80 metres. Headings not advanced.

Feb.—All timbers in the length of soft sandy mud replaced by rolled iron I sections built into frames, 2·8*m.* × 2·5*m.*, and continued up to face of heading. Headings not advanced.

Mar.—Driving by scraping into the wet material by means of short drifts, every inch being shored as soon as possible. Monthly advance, 15 metres; total, kilom. 4,443. Rock is veined with quartzite, and firmer.

Mar.—North end. Total advance, 6,880 metres. Rock: Compact dry schistic gneiss of Monte Leone.

Apl.—South end. Monthly advance, 14 metres (to kilom. 4·457). Water influx continued from kilom. 3·85 to kilom. 4·4 The difficult section of wet slate clay continued from kilom. 4·118 to kilom. 4·46. Iron frames, with spaces filled with concrete, employed wherever the pressure was great.

May 20.—Machine boring recommenced at south face, and heading advanced 68 metres (to kilom. 4·548).

Jun. 7.—South end. Machine boring recommenced in No. 2 heading. Rock: Anhydrite, very friable in the fingers, and the record for monthly advance made = 7·93*m.* per day. Accident in the enlargement section, a miss-fire cartridge being struck. Several workmen injured and killed.*

Jul.—South end. Dolomitic zone ended at kilom. 4·940, and succeeded by crystalline schists stratified with crystalline limestone veined with calcite and quartz up to kilom. 5·327, where schistic gneiss commences.

Aug.—North end. Rock temperature rose from 42° C. in the second quarter of year to 48° C. in third quarter. Ice making, for the trains of ice and other refrigerating installations in tunnel, commenced at Brig. General temperature of air in headings reduced from 31° to 30° C., and, in the fourth quarter, to 28·6° C. Numerous refrigerating sprays of cold water were introduced into the tunnel by means of a special Sulzer centrifugal pump, and in the fourth quarter a second pump was laid down; the two furnishing 55 litres of water per second.

Sept.—South end. The great cold springs at kilom. 4·4 diminished to 200 litres per second. Kilometric advance, 5·327.

Nov.—North end. Decomposed mica schists necessitated heavy timberings.

Dec.—South end. The horizontal stratification of rock (schistic gneiss) lessened the blasting effect of dynamite, and the number of rock borers were increased from 3 to 4 at each heading face, and the number of blast holes from 11 to 16.

Dec. 31.—South end. Total advance, 5,860 metres. Tem-

*The writer was in tunnel at time of explosion.

perature of rock at heading, 31° C.; of springs, 34° C.; and of air, 30° C. North side: Total advance, 8,470 metres. Rock: Mica schists of granatiferous character, necessitating heavy timberings. Rock temperature, 53° to 54° C.

1903.

Jan.—South end. Pebbly gneiss continues—kilom. 5·326 to 6·830.

Jul. 22.—North end. Highest point in tunnel line reached.

Jul.—South end. Zone of micaceous limestones and micaceous schists entered—kiloms. 6·830 to 7·750, and the first hot spring (20 litres per second) on that side met at kilom. 6·944. Lowest air temperature at heading, 27° C., outside air being 16·6° C.

Aug.—North end. At kilom. 9·950, at termination of dolomitic limestone and beginning of crystalline micaceous limestone, springs of 52° C. were tapped. Rock temperature, 52° C. Air at heading, minimum temperature, 26·7° C., with air outside tunnel, 17·5° C. Two centrifugal pumps working in series at 27½ atm. and 875 revs. per minute furnish 48 litres of refrigerating water per second to No. 1 heading. Heat extracted, 3,092,000 calories per hour.

Oct.—Work frequently interrupted by hot springs at north end. Heavy plant installed for dealing with the high temperature and pumping out water on down grade.

Nov. 22.—Heavy inrushes of hot water stop work at north end (kilom. 10·144) during the month following.

Dec.—South end. Advance, 7,752 metres. Rock: Crystalline calcariferous schists. Fairly dry. Rock temperature, 38·6° C.; air, 26° to 27° C.

1904.

Jan.—North end. Pumping out water in No. 1 tunnel while boring in No. 2.

Mar. 20.—Work recommenced in Tunnel No. 1 (north) with rock borer. Rock: Crystalline limestone, silicious and much broken.

May 18.—North end. Tapped a hot spring of 35 litres per second, which caused stoppage of mining, as the water power for pumping and refrigeration was working to its full capacity.

May 28.—A landslip near the intake of the hydraulic station interrupted working of ventilators and pumps. Hasty abandonment of the headings and closing of iron doors across tunnel. North end headings remain closed up until tapped by the workings from the south.

Jun.—Workings from south continued. Advance, 8,720 metres. Rock temperature, 39° C.; air at headings, 27·8° (min.), outside being 14·5°. Rock: Granatiferous mica schist (with garnets). Maximum summer flow of infiltrations, 1,153 litres per second.

Aug.—Rock heat at headings, 42·5° C.

Sept. 6.—Heading crown caves in with an irruption of hot water, 70 litres per second, at 45° C. Kilom. 9·110.

Oct.—No advance in tunnel No. 1. Installation of plant to deal with heat.

Nov.—Still at kilom. 9·110. Water inflow increased to 90 litres per second. North end: Works finished for cross-over roads at station in mid-tunnel. Bridge completed over Saltina at Brig, as also locomotive sheds in reinforced concrete to south of Brig station.

Dec. 19.—South end. Avoiding hot springs by advance through No. 2 tunnel, and by transverse gallery at kiloms. 9·126—9·140 into No. 1 again, where, on the 19th, machine boring was continued northwards. Total advance, kilom. 9·162.

Dec.—Only 192 metres separated the headings. Rock: Crystalline schistic limestone; veins of quartz and calcite. Rock temperature in heading, 45° C.; air temperature, 30·6° C.; outside temperature, 5° C.

1905.

Jan.—By hand excavation and boring, 83 metres of advance.

Feb. 24.—South heading meets at 9354 (S.) or 10376 (N.) the north heading, at 7.20 a.m. Water imprisoned between the rock diaphragm and safety gates, closing north end, passes off to the south end safely.

Jul.—Meeting of advance headings of No. 2 tunnel. Water at 47° C. rendered this last work very difficult.

Sept. 15.—Enlargement of tunnel to full section at south end completed.

Sept. 28.—Enlargement of tunnel to full section at north end completed.

Oct.—Masonry lining completed at north end on the 13th and at south end on the 18th.

Dec. 19.—Federal Government signs contract for a conditional application of electric traction in tunnel.

1906.

Jan. 25.—Line's standard gauge laid in tunnel. First train passes through the tunnel.

Feb. 20.—Railway in tunnel, with full equipment, completed.

May 19.—Inauguration of tunnel.

Jun. 1.—Tunnel open for regular traffic.

Jul.—Tunnel worked by steam locomotives exclusively.

Jul. 19.—The Federal Council approved the financial plan for the line and the works of the Loetschberg tunnel—so important for the eventual success of the Simplon route to Italy.

Aug. 1.—Electric traction substituted for steam-traction in the tunnel.

Sept. 22.—New station approach lines completed.

Sept. 25.—The monument celebrating the work of the Simplon route inaugurated at Arona (Lago di Maggiore).

The principal constructive feature of the boring of the Simplon tunnel was the secondary gallery, or tunnel No. 2, without which it is very doubtful if, having regard to the difficulties actually encountered, the work would have ever been brought to a successful termination. By reason of its low level the difficulty of the boring itself was greater, but the low level of the tunnel enabled the constructors to command a greater volume and head of water for motive power than is usually possible with mountain tunnels at high level. The low level also enabled the gradients to be easier than those of any other mountain main line railway in Europe.

Despite the various hindrances which occurred during the boring of the Simplon the progress effected by the machines was comparable with that of the Arlberg high-level tunnel in which the difficulties were much less. Comparing the boring of four great mountain tunnels, we find as follows:—

	Height of portals above sea level. Metres.	Length between ends of alignment galleries. Metres.	Area of tunnel headings. Sq. m.	Advance per month, total of two headings. Metres.	Daily advance by machines, total of two headings. Metres.
Mont Cenis—					
North	1,203	12,233	8	77	3.30
South	1,333	—	7	—	—
Gothard—					
North	1,109	14,912	6.40 mean	167	6.00
South	1,145	—	—	—	—
Arlberg—					
East	1,303	10,260	6.90	252	8.85
West	1,217	—	—	—	—
Simplon—					
North	686	19,729	—	—	—
South	634	—	6.00	252	10 63

From the foregoing it will be apparent that the progress made in the Simplon was largely attributable to the rock borer employed. Other improvements in equipment and processes also contributed, as will be best shown in tabulated form, as follows:—

	Duration of work in advance headings.	Type of rock-drill and number at each face.	Explosive used per lineal metre of advance.	Rock	%
Mont Cenis	13 ys. 2 ms.	Sommeiller compressed air, 7 to 12.	picric powder, 41 kgs. av.	schistic limestone	77
				gneiss	17
				limestone	3
				quartzites	3
Gothard	7 ys. 5 ms. 2 days.	compressed air drills, many types, including Ferroux (north side) and MacKean-Seguin, 5 (south side).	dynamite, 20 kgs. av.	micaceous gneiss	50
				finsterar, horn, granitoid	14
				gneiss, mica-schist and cipolin	16
				granatoids and calcareous	20
Arlberg	3 ys. 4 ms. 2 days.	Ferroux, 6 to 8 on East, and Brandt hydraulic, 2 to 4 on West.	dynamite, 18 kgs. av.	mica-schists, quartzites, granatoids, calcites, &c.	
Simplon	6 ys. 6 ms. 17 days.	Brandt, new type, 3 on North, 3 to 4 on South.	gelatine, dynamite, 26·2 kgs.	calca-schists	36
				gneiss	54
				mica-schists	10

From the above it is evident that the Simplon represented unusually heavy boring work to which the Brandt rock borer was appropriately suited—more so than at the west side of the Arlberg, where the rock was less solid than on the east side. This explains also the relatively large quantity of dynamite also consumed. More power was also necessary—not for the relative force actually developed at the cutting

points of the borers or per square inch of material removed in the bore holes, but for the greater resistance offered by the rock excavated. The long period of heat at the north side of the Simplon also absorbed a very large part of the power for refrigeration until, finally, with the additional power required for pumping out the water (while on the southward down grade) which had been pumped in for refrigeration purposes—added also to that due to natural inflows—the work was brought to an end, not only for want of power, but for want of room in the tunnel to pass the water in and out, if additional power had then been provided. The smallness of the Simplon tunnel advance headings, while economical and facilitating rapid construction, ultimately proved to be embarrassing for the transport services.

The following table shows for comparison the *nominal* power, etc., provided for various similar undertakings :—

	N.H.P.	Temperature of rock. Maximum.	Water inflow per sec.	Total cost of per lineal metre.
Mont Cenis—				
North	680	29°.5C	1·54 galls.	£220
South	700			
Gothard—				
North	1360	30°.5C	76·56 galls.	£180
South	1080			
Arlberg—				
East, West	Aver. 700	18°.5C	4·18 galls.	£186
				Estimated cost of completing two tunnels.
Simplon—				
North	Av. 2300	54°.C	44 galls.	
South	Av. 2000	47°.C	253·7 galls.	£220
			Maximum—283·8 galls. Sept. 30, '05.	

As a financial undertaking the superiority of the twin tunnel system has already been mentioned (see *Railway Engineer*, p. 78; March, 1906). The price mentioned above for the Simplon includes the enlargement of No. 2 tunnel to full section, as No. 1, and completely finished with one track.

The system of advancing by crown drifts was adopted at both faces and subsequently abandoned for the ordinary system of advancing along the base line of tunnel, and then, at once, enlarging outwards and upwards to full section. The principal engineers at both ends gave the writer strong reasons in support of the latter method wherever possible, and especially where good ventilation to cope with heat is required. Some crown drift sections—always insufficiently ventilated—often lagged behind, the result being that the incompleted section formed an obstruction against the free ventilation of the workings.

The most difficult constructive work in the whole tunnel was the building of the great arch ring in that portion of the tunnel which was driven with the aid of heavy iron frames. This remarkable work, which elicited the admiration of experts from all parts of the world, will be found partially illustrated in this article. The incalculable pressure in this portion of the tunnel, due to the decomposed mica-schist—which rapidly worked into black mud when trampled underfoot—caused the iron frames to buckle, bend and tear like pieces of tin plate. They resisted better when concrete fillings were employed instead of oak; the frames then became an iron-reinforced concrete wall.

For any future work through similar rock the experience thus gained suggests to the adoption of rolled iron rings made in two pieces to be bolted together and filled up with concrete. The lessons to be learnt from the construction of this part of the tunnel are of more interest than the study of the construction in any other portion.

From the mechanical point of view the installation of machinery made use of in the north headings between kiloms. 12·553 and 12·581 was the most remarkable. Such a plant operating under such extreme local difficulties, so far removed from the source of power and in such confined quarters, was unique in tunnel engineering. The whole conception, having regard to the traffic arrangements in such a confined space, impresses one by reason of its advanced engineering skill. This plant was worked to its extreme capacity but reached a point beyond which nothing further could avail. The principal factors were :—

1. Pumping out the hot water which, on the downward incline to Iselle, flowed into the headings and tended to swamp the bore holes for the dynamite.
2. Cooling the air by cold water sprays, the drainage of which flowed towards the portals.
3. Hydraulic power for all the turbines, pumps, ejectors, rock borers, etc., most of which water was discharged on the same downward gradients to the portals.
4. Pumping out this water.
5. Driving air forward from tunnel No. 2 into the main heading No. 1, and keeping the ventilating pipe cool by circulating cold water in jackets round it or injecting cold water sprays into the pipe.
6. Insulating the cooling water pipes by a jacket of broken charcoal to keep water cool in its passage through the warm air.
7. Covering the large drainage pipes with wooden lagging to prevent their heating the air in their passage through the tunnel back to the portal at Brig.
8. Closing in all the hot springs by several thicknesses of planks to prevent radiation of heat near headings.
9. Provision of cold water to throw on to the inbursts and so reduce their temperature at the entry into the workings.

All these pipes left but little room for the passage of the spoil and material trains which were hauled by air-worked locomotives. Accidents were inevitable although remarkably low considering the conditions—the difficulty of seeing through the fog caused by the condensation of the hot vapors on the cold water sprays and laden with the sulphurous fumes from the dynamite explosions. The only light in the headings was that given by the miners' oil lamps. Here it may be remarked that in the Simplon tunnel work electricity in any form was strictly and rigidly excluded. Although largely employed for illumination outside the tunnel, its use in the tunnel itself was considered to be unreliable ("capricious," to use an Italian expression) and potent in danger. Even in the traction of spoil trains outside the tunnel at the southern end (Mediterranean Railways of Italy) its unreliability for rough work was to be seen daily in its substitution by steam locomotives, upon a line having electric transmission and using water as the prime mover.

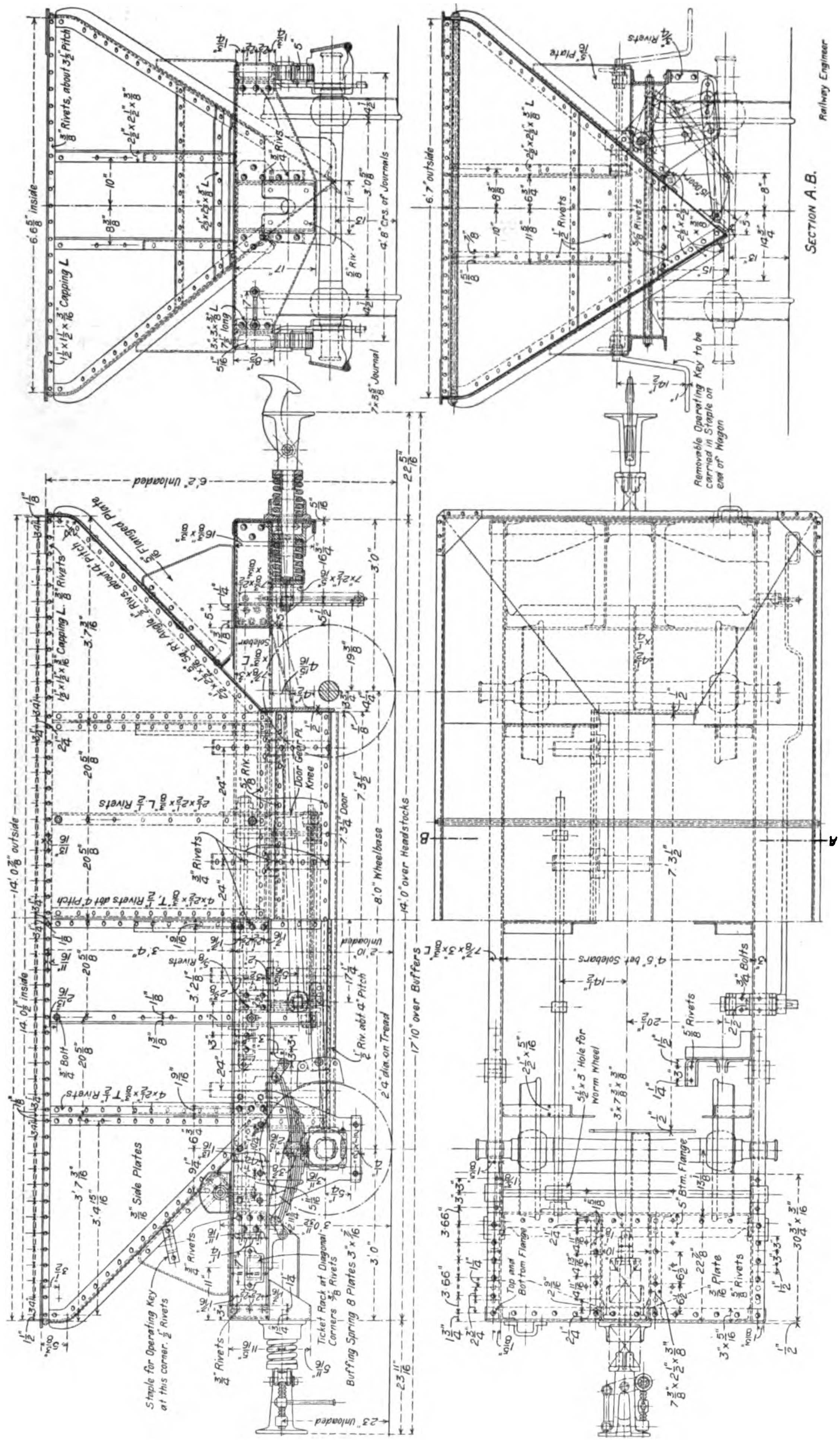
The Simplon enterprise was admirably organised. The sanitary arrangements in the tunnel were modern, and the strictest discipline was enforced in all hygienic matters. Pure drinking water was provided, and any contamination was guarded against. In the Gothard boring the arrangements were deplorable in this respect, and hundreds fell victims to a terrible anemia provoked by an intestinal parasite, the *duodenal ancilostoma*, which malady was unknown in the Simplon where, however, a much-dreaded trouble (at the south side) was a sort of blood-poisoning, due to long contact of the limbs with the flood water in which the fumes of the dynamite had been condensed. This water often covered the floor to a considerable depth until drains could be made deep enough to lead it into No. 2 tunnel.

(To be continued.)

Ballast Wagons and Spreading Plough-Vans for Metre Gauge Railways.

THE annexed drawings and views illustrate a large number of hopper ballast wagons and the underframes and spreading ploughs for plough-vans, which have been constructed to the requirements of Messrs. Rendel and Robertson, of Westminster, by the Leeds Forge Co., Ltd., for the Assam-Bengal and the Burma railways. Similar vehicles are of course suitable for other than metre gauge railways.

It will be noticed that the hopper wagons are of a similar type to the ballast wagon, fig. 20, illustrated on p. 368 of our last issue, with the exception that the gear for operating the doors is on Jepson's patent and consists of two toggle

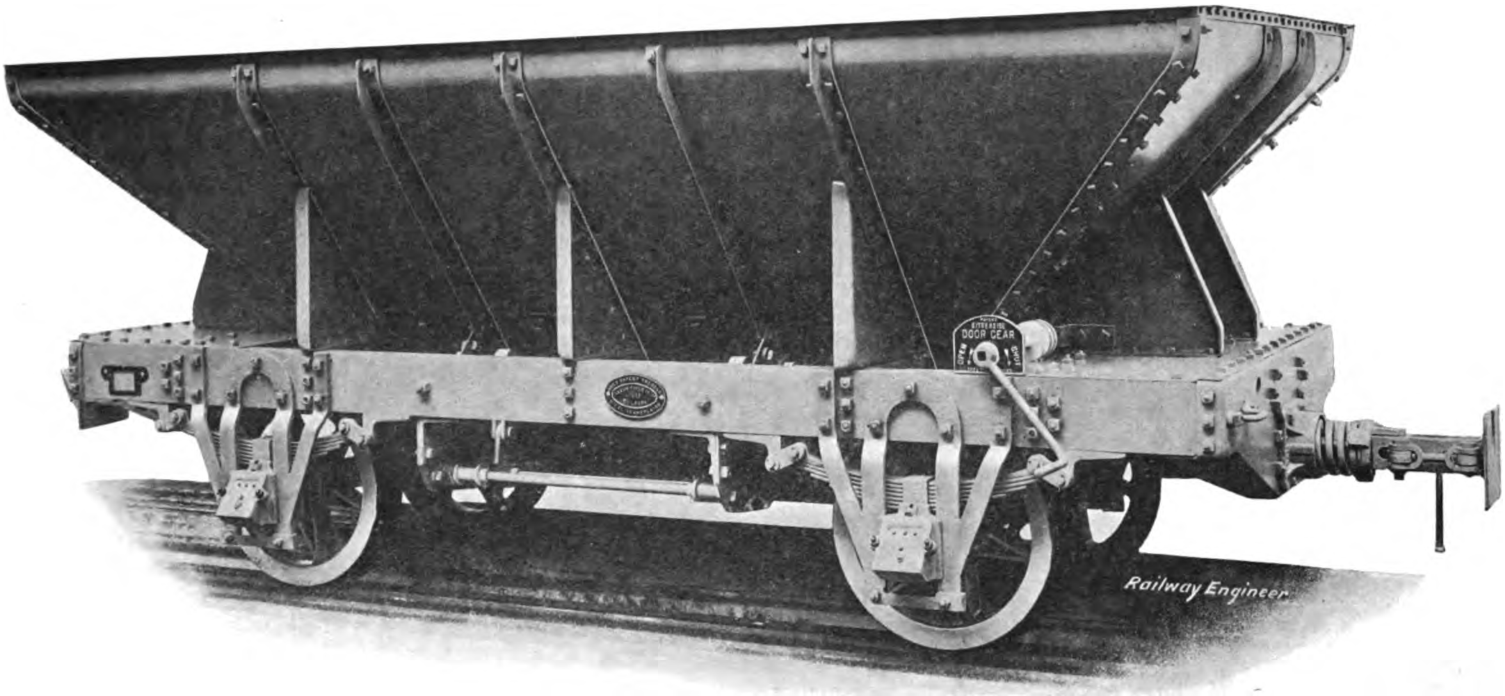


Hopper Ballast Wagon; Burma Railways.

joints, worked from either side of the wagon by means of a worm and wheel, and which are straightened when the doors are closed, and thus automatically lock themselves. This gear has been largely used on hopper wagons of all sizes, and has the great advantage of being absolutely safe to the men working it, as the doors can be opened to any intermediate position without the least jerk, and are held there automatically by the gear, and the doors may be further operated from either side, irrespective of the side from which the last operation was made.

The worm is mounted on a cross shaft at one end of the wagon, and the fixed centres of the toggles on longitudinal shafts carried in brackets riveted to the underframe.

The construction of the wagon is clearly shown on the drawing. The hopper sides are of steel plates $\frac{3}{16}$in. thick, stiffened with angles $2\frac{1}{2}$in. by $2\frac{1}{2}$in. by $\frac{3}{8}$in., and T's 4in. by $2\frac{1}{2}$in. by $\frac{3}{8}$in., fastened by the $\frac{1}{2}$in. rivets about 4in. pitch. Round the top is a steel angle $1\frac{1}{2}$in. by $1\frac{1}{2}$in. by $\frac{3}{16}$in., riveted with $\frac{3}{8}$in. rivets pitched about $3\frac{3}{8}$in. To prevent the hopper bulging there are two $\frac{3}{4}$in. tie bolts, which are put through tubes which protect the bolts and stay the inside. The bottom door is 7ft. $3\frac{1}{4}$in. long clear carried on four hinges. The ends of the apex of the hopper are $\frac{1}{2}$in. thick, stayed by pressed



Hopper Ballast Wagon ; Burma Railways.

steel flanged plates to the cross bearers, which are also of pressed steel plates $\frac{3}{8}$in. thick and $7\frac{3}{8}$in. deep, with 3in. top and 5in. bottom flanges. The ends of these cross-bearers are riveted to the sole bars (which are channels $7\frac{3}{8}$in. by 3 in. by $\frac{3}{8}$in.) and to the headstocks by short longitudinals $7\frac{3}{8}$in. by $2\frac{1}{2}$in. by $\frac{3}{8}$in. The headstocks, which are 17in. deep in the middle to carry the central buffer Norwegian hook-coupling, are of $\frac{5}{16}$in. plate flanged all round as shown to connect with all the adjoining members, with only two angle pieces. The ends of the underframe are covered on the top with $\frac{3}{16}$in. plate, fastened with $\frac{5}{8}$in. rivets. The sides and ends of the hopper are supported from the underframe by flanged $\frac{5}{16}$in. plate brackets. The wedging strain due to the load is taken off the sole-bars by two through bolts, stayed with tubes, as shown on the drawing.

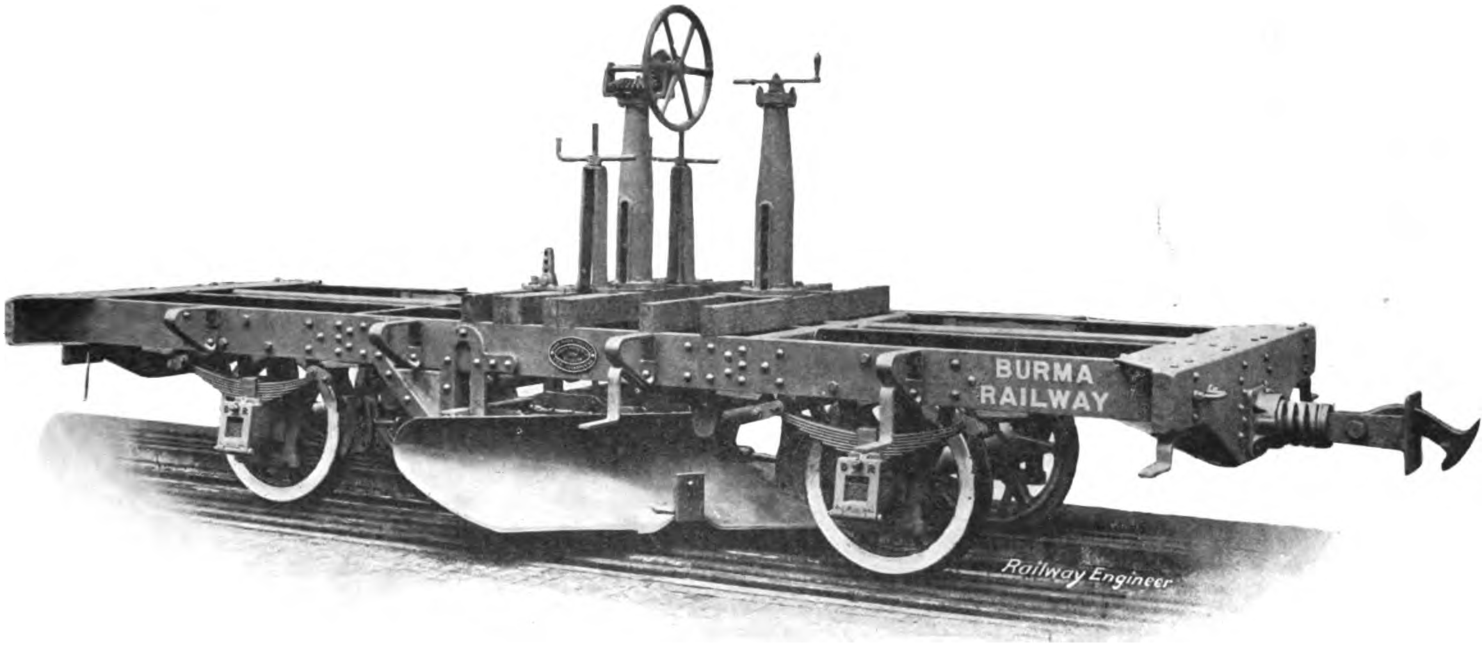
The top of the hopper is 14ft. $0\frac{1}{2}$in. long by 6ft. $6\frac{5}{8}$in. wide inside and the height from the rails (unloaded) 6ft. 2in.

The wheels are 2ft. 4in. diam. on the tread, the axle journals 7in. by $3\frac{3}{8}$in., and the wheel-base 8ft.

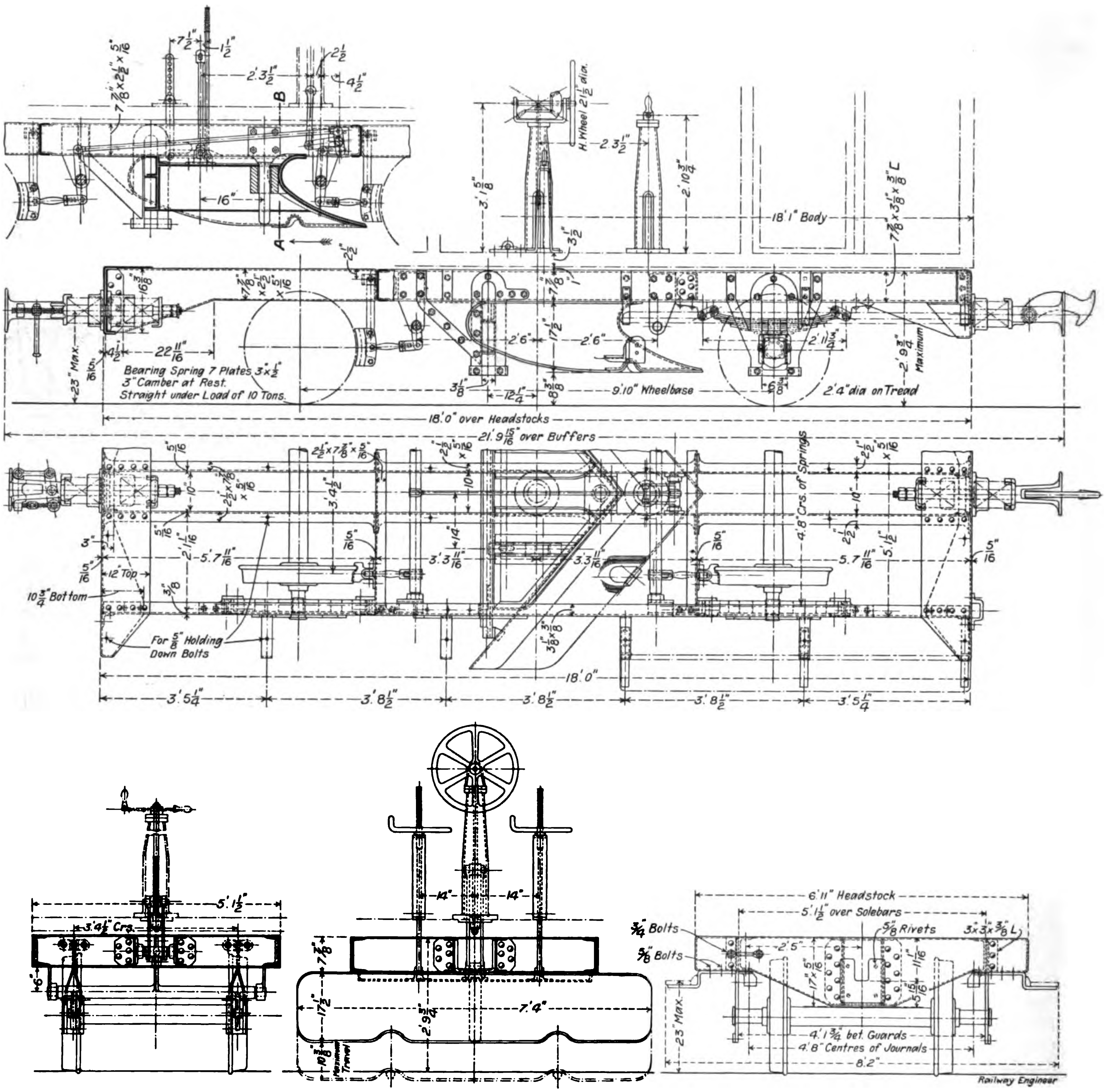
The length over the headstocks is 14ft., and over the buffers 17ft. 10in.

Underframes for Spreading Plough Van.

This underframe is of very simple construction, no diagonal members being required, the corners being tied only by the wide flanges of the pressed $\frac{5}{16}$in. plate headstocks. The sole-bars are steel channels $7\frac{3}{8}$in. by $3\frac{1}{2}$in. by $\frac{3}{8}$in., but



Underframe for Plough Van ; Assam-Bengal Railway.



Section A.B. Section A.B. (looking in direction of arrow). End View.

Underframe for Plough Van; Assam-Bengal Railway.

otherwise all the members are $\frac{5}{16}$in. plates flanged to $7\frac{7}{8}$in. by $2\frac{1}{2}$in. by the lengths given on the drawing.

The plough is of the usual construction. Its vertical travel is guided by a pin at the back of the apex bolted to the middle longitudinals of the underframe and by strong brackets bolted to the sole-bars, and which thrust the plough forward. The plough itself is stiffened at the back by flanged plates, to which are attached the lifting links. The main lifting and lowering screw is worked by the hand-wheel and spur and bevel gear, but there are two auxiliary lifting screws by which the weight of the plough is taken off the main screw and is drawn hard against the underframe when the van is travelling or not in use. There are also two suspending links at the back end of the plough, drilled and fitted with pins. All the wheels have brake blocks worked from the standard in the usual way.

The bodies for these vans were built in India.

New South Wales Government Railways, 1907-8.

The Chief Commissioner, Mr. T. R. Johnson, in his annual Report to the N.S.W. Parliament upon the working of the railways and tramways during the year ended 30th June, 1908, states that the net result was:—

Sydney, 27th July, 1908.

To the Honorable the Minister for Railways.

Sir,—In accordance with the provisions of section 44 of the Government Railways Act of 1901, as amended by the Railway Commissioners Appointment Act, 1906, I have the honour to submit, for the information of Parliament, my Report upon the working of the Railways and Tramways for the year ended June 30th, 1908.

The results of the working of the railways and tramways, compared with the previous year, are as follows:—

	Railways.	Tramways.	Total.
Earnings	£4,944,134	£1,011,994	£5,956,128
Working expenses ...	£2,714,839	£809,065	£3,523,904
Balance	£2,229,295	£202,929	£2,432,224
Interest on capital ...	£1,649,364	£134,504	£1,783,868
Surplus	£579,931	£68,425	£648,356

The surplus for the year 1906-7 was £659,916.

The number of miles of line open on the 30th June last was 3,472½. About 19 miles were opened for traffic during the year, about 185½ were under construction, and 391 authorised for construction.

The expenditure charged to capital account during the year amounted to £983,254, making the total capital expenditure on lines open for traffic on the 30th June, 1908, £45,683,484.

Although reductions in rates and fares operated throughout the year to the extent of about £214,000, the total earnings amounted to £4,944,134, as compared with £4,709,406 for the previous year, being an improvement of £234,728, or 4.98 per cent.

Owing to the large increase in the number of passengers and the tonnage of goods, minerals, and live stock traffic, the train miles show an increase of 1,301,984 miles.

After meeting the additional expenditure required to work a larger traffic, to make good the reduction in rates and fares, making liberal provision for the general upkeep of the property, and providing a sum of £28,277 towards writing off the capital cost of works demolished at the old Redfern Station, and the Sodwalls deviation, the total working expenses amounted to £2,714,839, as compared with £2,499,741 for the previous year, an increase of £215,098.

The percentage of working expenses to earnings is 54.91 per cent. as compared with 53.08 per cent. last year.

The net result, after providing for all working expenses and £1,649,364 interest on the capital invested, is a surplus of £579,931 as compared with a surplus of £610,955 last year.

Additional safety appliances and improvements have been made at various places, and every reasonable precaution has been taken to insure safe working, but much requires to be done in the interlocking of points and signals at many of the larger stations, and provision is being made to proceed with these improvements within the current financial year. In this connection, it may be stated that during the past seven years, 258,620,836 passengers have been carried, and only one member of the travelling public was fatally injured owing to accidents to passenger trains.

The large reductions in rates and fares made prior to July, 1907, and subsequently, operated throughout the past year to the extent of about £174,000; and further reductions amounting to about £40,000 were made in the carriage of starving stock.

The volume of traffic continues to show remarkable development. For the past year, passengers increased 6,073,946; and goods, mineral, and live stock, 1,381,557 tons; and during the past five years passenger traffic increased 47 per cent., and goods tonnage 54 per cent.

It has been difficult to keep pace with this rapid expansion satisfactorily. The want of additional rolling stock, accommodation, and appliances generally has been severely felt. Additional rolling stock is daily coming forward; but, in the interests of economy, further supplies are necessary. The duplication of several sections of the line, where the traffic has outgrown single line working, additional sidings, station accommodation, and other facilities, are also urgently required.

Good progress has been made in necessary renewals, 590 miles of line were wholly or partially renewed, viz., 243½ miles completely or partially relaid, resleepered or re-railed, 68 miles strengthened by heavy angle fishplates at the joints, and 278 miles partially reballasted; 76,069 cubic yards of ballast or other hardstone were used for lifting and ballasting, and 31,888 cubic yards of sand and ballast to strengthen several of the light pioneer lines. Many of the smaller timber structures of bridges have been renewed in brick and steel, 211 miles 18 chains of fences have also been renewed, and in no previous year has the expenditure on the maintenance of buildings been so heavy—a very large number having been repainted and put in first-class order.

Results of the Working.

Expended on construction and equipment ...	£45,683,484†
Cost per mile open for traffic	£13,156
Total miles open for traffic	3,472½
Average miles open for the year	3,468¾
Earnings	£4,944,134
Working expenses	£2,714,839
Balance	£2,229,295
Profit on capital invested, per cent.	£4 17s. 7d.
Working expenses to earnings, per cent. ...	54.91
Earnings per average mile open	£1,425
Working expenses per average mile open ...	£782
Profit per average mile open	£643
Earnings per train mile	6s. 11¼d.
Working expenses per train mile	3s. 9⅝d.
Profit per train mile (after paying working expenses)	3s. 1½d.
Number of passenger journeys	47,487,030
Goods tonnage	9,719,840
Live-stock tonnage	455,549
Train mileage	14,251,052

† £511,210 of this sum was paid from the Consolidated Revenue, and no interest is payable thereon.

Summary of Ton Mileage for the Year.

Description of traffic.	Total carried. Tons.	Total distance. Miles.	Miles per ton. Aver.	Earnings ex. terminals. £.	Per ton mile. d.	Each class to total. %
Coal, Coke, &c.	6,490,594	152,097,989	23·44	334,469	·53	66·19
Other Minerals	356,642	18,156,353	50·91	53,702	·78	3 61
Crude Ores	117,271	10,871,640	92·71	23,881	·53	1·20
Miscellaneous	419,586	31,365,290	74·75	96,099	·74	4·28
Firewood	275,786	7,190,814	23·07	23,362	·78	2·81
Fruit	44,037	4,342,411	98·61	16,013	·88	·45
Grain, &c. "Up"... ...	300,384	67,556,806	224 90	100,818	·36	3·06
Hay, Straw, &c.	192,419	36,037,952	187·29	57,592	·38	1·96
Frozen Meat	7,635	494,098	64·71	2,064	1·00	·08
General (truck loads) ...	1,821	632,969	347·60	6,866	2·60	·02
A. Class	493,724	51,922,518	105·16	218,293	1·01	5·04
B. Class	250,990	28,802,866	114·75	204,711	1·71	2·56
C. Class	23,955	1,219,376	50·90	10,255	2·02	·24
1st Class	109,441	15,122,851	138·18	194,301	3·08	1·12
2nd Class	91,886	16,518,455	179·77	269,005	3·91	·93
3rd Class	46,910	7,064,113	150·59	142,606	4 81	·48
Wool Class	126,384	36,232,214	286·68	298,441	1·98	1·29
Live Stock	455,549	132,018,519	289·79	540,471	·98	4·65
Total	9,804,014	617,612,314	63·00	2,597,980	1·01	100·00

Miscellaneous traffic consists of timber, bark, firewood, bricks, drain-pipes, coal, road metal in 6-ton lots, agricultural and vegetable seeds in 5-ton lots, and traffic of a similar nature.

A and B classes consist of lime, vegetables, tobacco leaf, caustic soda and potash, cement, copper ingots, fat and tallow, water and mining plant, 6-ton lots; leather, 1 and 3-ton lots; agricultural implements in 5-ton lots; and other traffic of a similar nature.

This statement does not include 371,375 tons of coal, on which only shunting and haulage are collected; nor does it include £48,221 for haulage, tonnage dues, &c.

Summary of the Mileage of Suburban (within 22 miles of Sydney and Newcastle) Passengers.

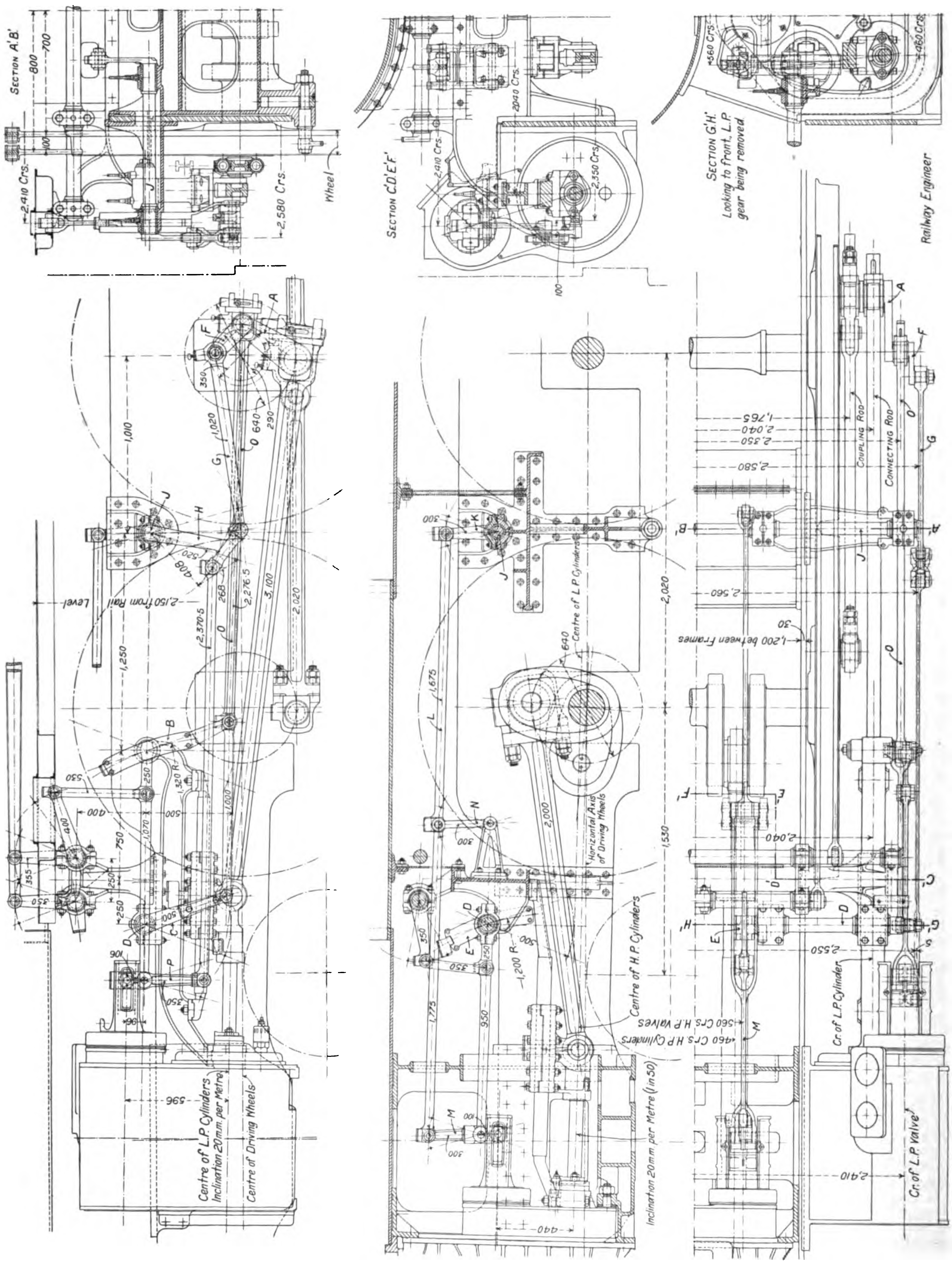
Number of ordinary passengers...	17,170,130
Number of season ticket holders' journeys ...	13,482,120
Number of workmen's journeys	10,751,772
Total number of passengers' journeys ...	41,404,022
Number of miles travelled	258,145,729
Average mileage per passenger	6.23
Amount received from passengers	£455,021
Average receipt per passenger per mile	0.42d.

Summary of the Mileage of Passengers on the Extended (between 22 and 34 miles from Sydney, and including Richmond and Branxton) Suburban Section.

Number of passengers	1,326,018
Number of miles travelled	26,318,957
Average mileage per passenger	19.85
Amount received from passengers	£49,625
Average receipt per passenger per mile	0.45d.

The number of miles of line open on the 30th June last was 132¾. The expenditure charged to capital account during the year amounted to £63,467.

The total capital expenditure on lines open for traffic on the 30th June, 1908, was £3,732,991. The total earnings amounted to £1,011,994, as compared with £908,701 last year, being an improvement of £103,293, or 11.37 per cent. After making liberal provision for the general upkeep of the property and providing a sum of £25,000 to clear off the capital cost of the old cable plants, conduits, etc., of the North Shore and Ocean Street lines, £32,000 on account of old steam motors, and £25,000 toward depreciation of the Ultimo Power House machinery, the total expenditure amounted to £809,065 as compared with £727,947 the previous year, an increase of £81,118, or 11.14 per cent. The percentage of expenditure to receipts is 79.95 per cent., as compared with 80.11 per cent. last year. The net result, after providing for all working expenses and £134,504 interest on the capital invested, is a surplus of £68,425, as compared with £48,961 last year.



Valve Gear of 4-6-2 or "Pacific" Type Express Engines; Western Railway of France.

During the year 172,020,932 passengers were carried, and although unfortunately one accident resulted in the death of two employees, of the total number of accidents, 88 per cent. were due to the want of caution on the part of the injured. No passengers were fatally injured directly resulting from accidents to the trams, and in this respect, only two passengers have been fatally injured through accidents to trams for the past eight years, during which time the number carried was 1,082,058,863.

Railways and Tramways.

The staff employed on the 30th June numbered 22,971, viz.:—Railways, 17,924; tramways, 5,047. Full classification and merit advances were granted during the year to the extent of £99,000, of which the wages staff received £83,250. The working time of the station officers has been reduced to six days per week, and the conditions of the staff in other directions have been improved.

Valve Gear of 4-6-2, or "Pacific" Type Express Engines; Western Railway of France.

In accordance with the promise in our "Locomotive Notes" for September, we now give the annexed drawings and description of this interesting design of valve gear. Recapitulating the main features as regards the relation of the cylinders, etc., to the wheels, it may be first noted that, contrary to usual French practice, the low-pressure cylinders are outside the frames, driving the middle coupled axle, while the high-pressure cylinders are placed between the frames well forward of the smoke-box saddle and drive the leading axle, which is cranked in the usual manner with hooped elliptical cheeks instead of having an oblique centre portion connecting the two crank pins. The four cranks are placed at 90° apart, each H.P. and L.P. crank being at 180°.

The valve gear in its essential principles is of the Walschaert type, but instead of having a separate driving crank or eccentric for each valve, the motion for one set of inside and one set of outside gear is obtained from one return crank *A* attached to the outside main crank pin.

In addition to the return crank, placed at 90° in advance of the main crank, which gives the motion to the radius links *O*, there is another, *F*, mounted on the opposite centre to the main crank pin; this arm has for its function the actuating of the lap and lead or combination levers *P* and *M*, these latter being in ordinary Walschaerts gear moved from connections to the crossheads.

The opposite direction of travel for the two valves is obtained by a combination of two features, the placing of the reversing shafts back to back, so that the dies in the inside and outside expansion links are on opposite sides of their centre lines, and further, by arranging one lap and lead lever in the customary vertical position, while the other is inverted, that is its actuated end is above its fulcrum.

Referring to the annexed drawings, the upper views show the outside or low-pressure gear. Tracing the motion from the return crank *A*, which provides the travel for the valves, from this pin the connecting rod couples direct to the outside expansion link *B* in the usual manner, it then goes forward to the end of a lever *C* on a rocking shaft *D* in a bracket, the other end of this shaft carries the expansion link *E* for the inside or H.P. valve; the bearing bracket is mounted on the slide bar carrier bracket.

As before-mentioned, the two lap and lead levers receive their motion from a common source, namely, the second return on the crank pin *BF*. Again referring to the upper view of the drawings, it will be seen that from this pin a rod *G* is led, the other end of which is connected to one arm of a T-headed lever *H* on a rocking shaft *J*, the other arm *K* of which is inside the frames. From this upper arm a long connecting rod *L* reaches forward to the top end of the inverted, H.P., lap and lead lever *M*. Owing to the great length of the connecting rod it is supported about midway by a swing link *N*.

Owing to the decreased length of the lap and lead levers compared with those operated in the usual manner, the lap of the valve has been decreased, thereby prolonged admission has been obtained, ranging in fact up to 90 per cent. of the stroke in both directions and in both cylinders, the result of which is marked when starting.

The whole of the design for this motion and its accompanying details will repay careful study, for not only does it represent the outcome of much scheming to overcome new conditions, but the details embody features of French practice not found in home designs, which are accordingly of great interest and very instructive.

As regards the use of steel castings, this material has freely been introduced so as to take advantage of its combined strength and lightness; the slide bars, which are all of the single type, are carried, in the case of the L.P. bar, by an elegant steel casting in the form of a girder, one end of which rests on the cylinder cover, and is supported about its middle by a cantilever bracket bolted to the frame; the outer end of the girder is unsupported and is bossed up to form the bearing for the expansion link shaft.

In the form of the coupling and connecting rods a typical feature of French design is seen. As regards the H.P. connecting rods and also the coupling rod ends, they are of the same form, namely a modification of the marine pattern, in which the two longitudinal bolts are replaced by one of U form, which is made to embrace the outer brass, thus combining the function of the bolts and rod end piece.

The L.P. connecting rod big end is of the open fork pattern, depending on the cotter alone to resist the shearing stress; the fork is prevented from opening by a continuous band or strap placed behind the cotter and bearing against the outer flanges of the brasses; it is held in position by the cotter. A similar end is used for the main eccentric rods.

Locomotive Journals and Bearings.—IX*.

Great Eastern Railway.

The work which locomotives have to perform on the Great Eastern system is peculiar and may roughly be divided into two classes. Firstly there is a suburban traffic unsurpassed in density and volume by that on any other railway, and the punctuality with which it has always been worked has justly excited the admiration of all railway men. Secondly there is the comparatively sparse long distance traffic which can only be worked profitably by collecting it into big units.

For the former traffic Mr. Jas. Holden designed special tank engines to suit the particular local services. But as the details we illustrate do not belong to those engines we are not now concerned with them.

The long distance trains, especially from London and Harwich, were for the reason above stated never light, and as corridor and restaurant carriages were introduced they gradually became very heavy, while at the same time their speed and the length between the stops were increased.

* Previous articles of this series appeared in February, March, May, June, July, August, October and November, 1908.

When in 1898 the 4-4-2 class and in 1900 the "Claud Hamilton" classes were turned out of the Stratford works it was generally admitted that the designs were very handsome, and the engines in work have since proved that they were as good as they looked. In the express engines subsequently built, boilers of the Belpaire type were adopted; but the design of the 4-4-0 engines remains substantially the same and all the heavy express trains on the Great Eastern R. are worked by them.

The Great Eastern R.—like the L and North-Western and Great Northern Railways—suffer from the disadvantage of having a steep rising gradient—1 in 72—close to its principal terminus. In the case of the Great Eastern R. there is the further disadvantage of a stop signal on the bank. In several parts of the system there are numerous short gradients of 1 in 100. In the holiday season the weight of trains often amounts to over 400 tons behind the tender. The longest non-stop run is from Liverpool Street to North Walsham, 130 miles, for which 158 minutes are allowed. The Continental boat trains run the 68¾ miles between London and Parkeston Quay in 87 minutes. In connection with the Continental service through carriages and restaurant cars are run to York and to Manchester, Liverpool and Birmingham, and a very long train is the result. The traffic to Yarmouth and other East Coast watering places is also exceptionally heavy.

The engines of which Mr. S. D. Holden, the present locomotive superintendent, has been good enough to give us drawings of the details illustrated have inside cylinders, 4-4-0 wheel arrangement and the following dimensions, etc.: —

Cylinders, 19ins. x 26ins.
Coupled Wheels, 7ft. diam.
Heating Surface, 1,706·6 sq. ft.
Great Area, 21·6 sq. ft.
Working Pressure, 180 lbs. per sq. in.
Weight, on the bogie, 17 tons 5 cwt. 1 qr.
Weight on the Coupled Wheels, 36 tons 8 cwt. 3 qrs.

Driving Horn-Block and Axle-Box, fig. 39,

The Horn-Block is a steel casting of the usual pattern, the horns being tied together by a wrought iron stay 1in. by 5⅜in., hooked at the ends and secured by three ⅞in. studs at each end as shown. The block is fastened to the main frames by fourteen turned bolts ⅞in. diam., the holes being carefully broached, when the block is in its position on the frame and the bolts made a driving fit. The wear of the box sides and horns is taken up by a cast iron wedge 5⅜in. by 16in., adjusted by an 1¼in. eye bolt, fitted with double nuts and locked in position by a nut 1in. thick. The wearing surfaces of the horn block are 5⅜in. wide and the thickness of its flange is 1¼in. The drawing is fully dimensioned.

The Axle-Box is of gun-metal and has a white metal inset (2⅞in. by 6¾in.) on each side of the centre line as shown. It is bored and faced for a journal 8½in. diam. by 8¾in. (*see* fig. 40) and is 8¹¹⁄₁₆in. long. The bearing is brought to the horizontal centre line on each side. The width over the

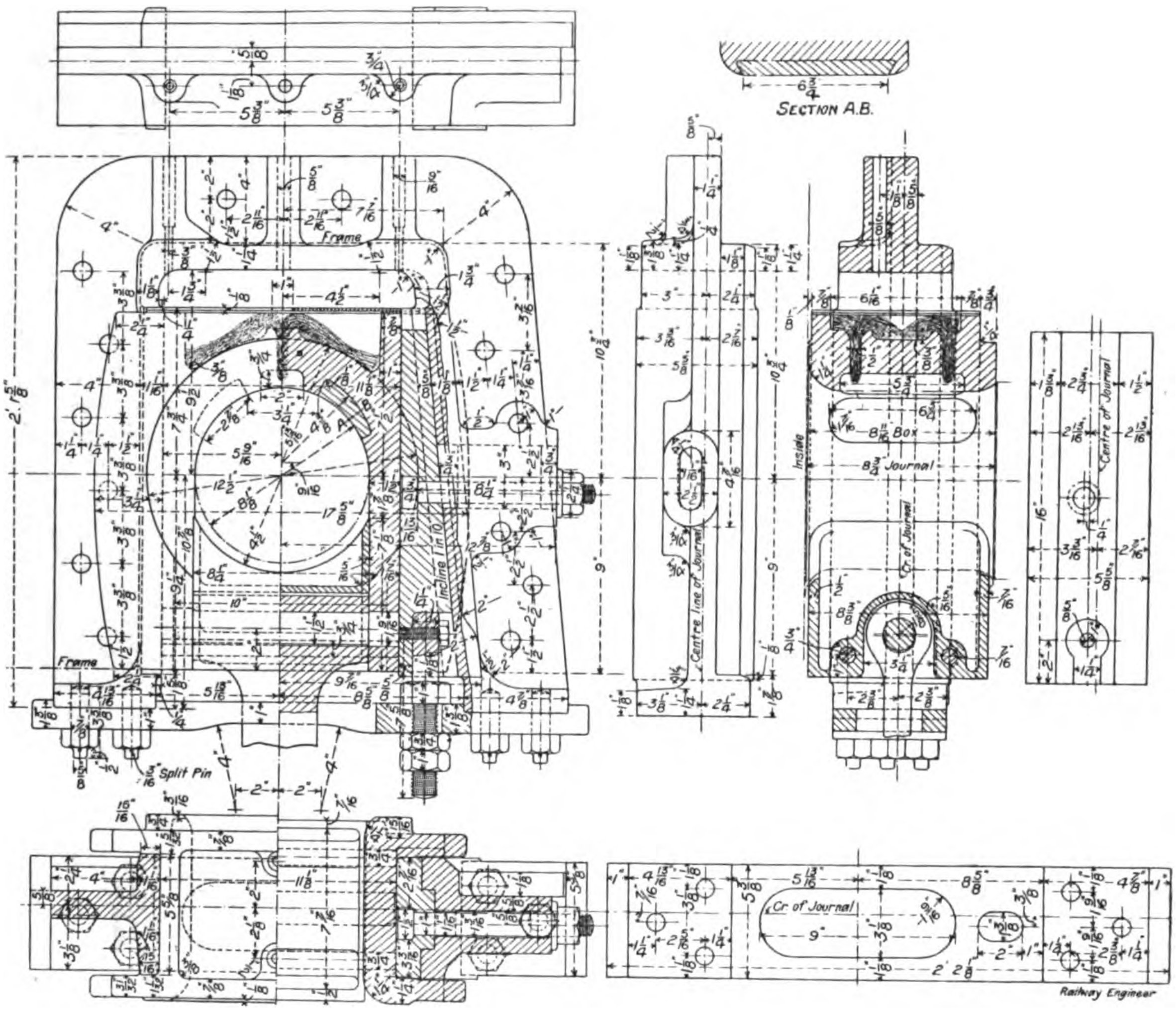


Fig. 39.—Driving Horn-Block and Axle-Box; Great Eastern Railway.

wearing surfaces is 11⅛in. and the depth from the top to the centre line 7½in. The horn surfaces are 16½in. by 5⅝in.

An oil chamber is cast in the top of the box, and from this the oil is syphoned by trimmings through two ½in. holes into a trough 5¾in. by 2in. by ¾in. deep along the crown of the bearing. The oil is supplied from one triple oil box on back of splasher through a ⅝in. hole in a web cast on the hornblock. The horn rubbing faces are lubricated from the same oilbox. The oil chamber is covered by a wrought iron plate resting on a leather washer.

The keep is of cast iron and is provided with a lubricating pad, which bears on the lower surface of the journal. It is fitted inside the axle-box and supported in its place by two ¾in. wrought iron pins.

The Spring-Link is of wrought iron and is connected to the box by a wrought iron pin (1½in. diam.), which has its ends increased to 1$\frac{9}{16}$in. diam. where they enter the gunmetal. The axle-box is designed for a load of 7 tons.

Crank-Axle, Fig. 40.

This is of steel, having a tensile strength of 30 to 35 tons. It is of the solid or all-in-one-piece type and has the circular webs, first introduced by Mr. T. W. Worsdell. The throw of the cranks, which are exactly at right angles, is 13in. The webs are 24in. diam. by 4½in. and 4in. The main journals are 8¼in. diam. by 8¾in. long, the big-end journals 8¼in. diam. by 5½in., and the wheel seats 9in. diam. by 8⅝in.

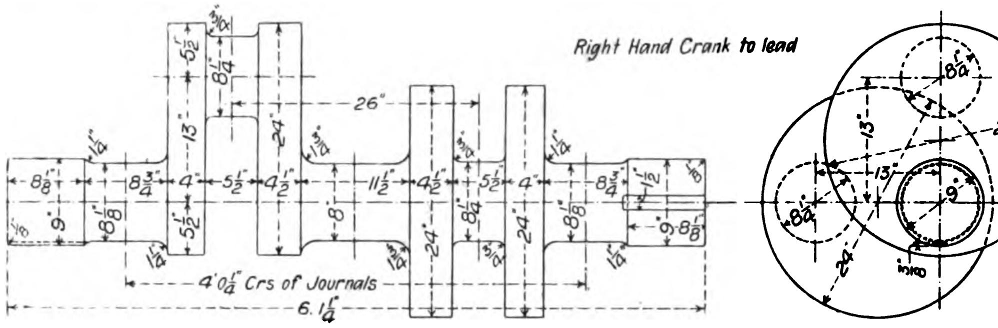


Fig. 40.—Crank Axle; Great Eastern Railway.

Connecting Rod, Fig. 41.

This rod is forged steel, and is 7ft. 7½in. long between the centres. The small end, the eye of which is 6½in. diam. by 3in. wide, is solid with the rod, which is 2in. wide parallel, but its depth tapers from 3¾in. up to 5½in., the corners being rounded off to a radius of ¼in. The butt end is 11¾in. long by 9⅝in. deep by 3¼in. wide, lightened by a round-ended hole 7½in. long by 4¾in. deep.

The Big-end Bearing is 8¼in. diam. by 5$\frac{7}{16}$in. long (*see* fig. 40). The brasses are attached to the butt-end of the rod by a square-ended steel strap 2⅜in. by 3¼in. middle section, and have flat seats 10½in. long by 9in. by 3¼in. wide, They have four dovetailed insets of white metal with wearing surfaces 2⅞in. by 4$\frac{3}{16}$in., and are kept in place by deep flanges all round as shown. The brasses are adjusted by a cotter ⅞in. thick and tapered on one edge at 1 in 16 and secured by two steel ⅝in. set screws and a safety split cotter ⅜in. by ½in. The cotter bears on the brasses by means of a steel wedge wholly enclosed by the flanges of the brass.

The strap is fastened to the butt end by two through bolts

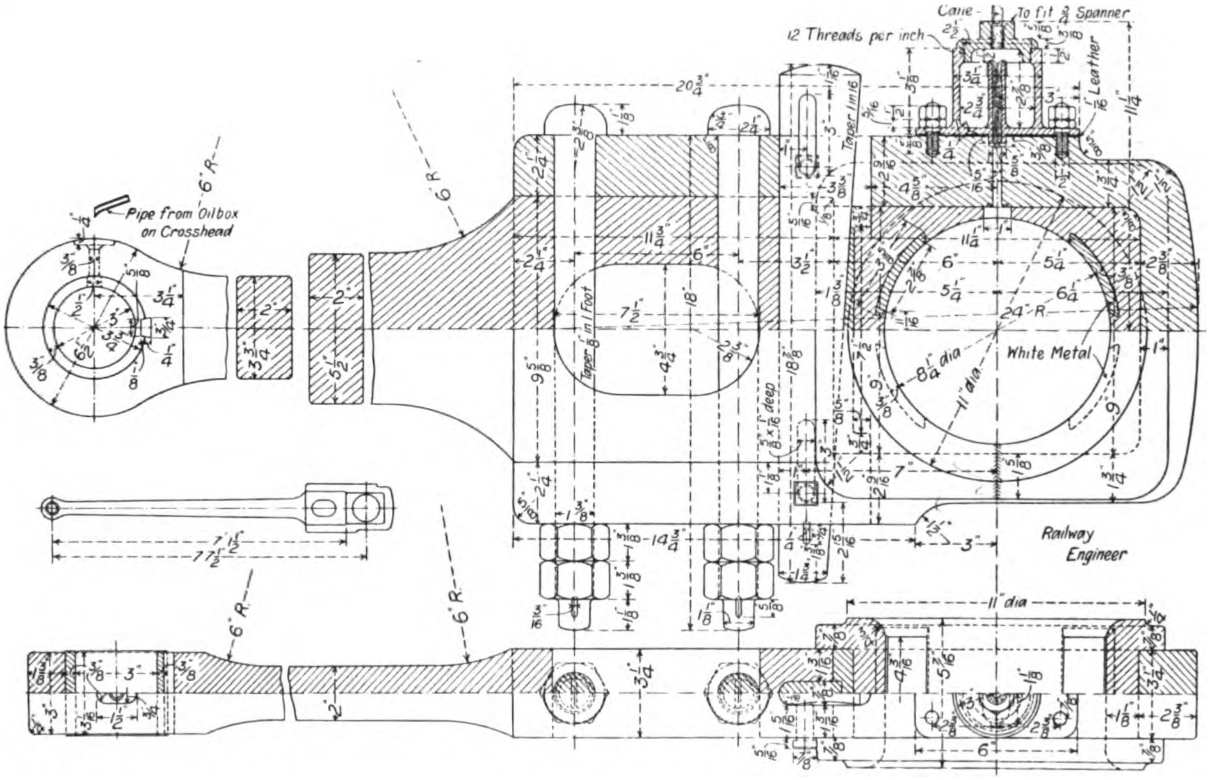


Fig. 41.—Connecting Rod; Great Eastern Railway.

tapered at $\frac{1}{8}$in. to the foot and $1\frac{3}{8}$in. smallest diameter. These bolts are fitted with double nuts and safety split cotters $\frac{5}{8}$in. by $\frac{3}{16}$in.

The Big-end of this rod resembles very closely that of the Great Central R., a drawing of which we published in our issue for last June, but in one feature it differs from all the other nine big-ends of which we have given drawings. It will be noticed that the oil cup, instead of being solid, is made

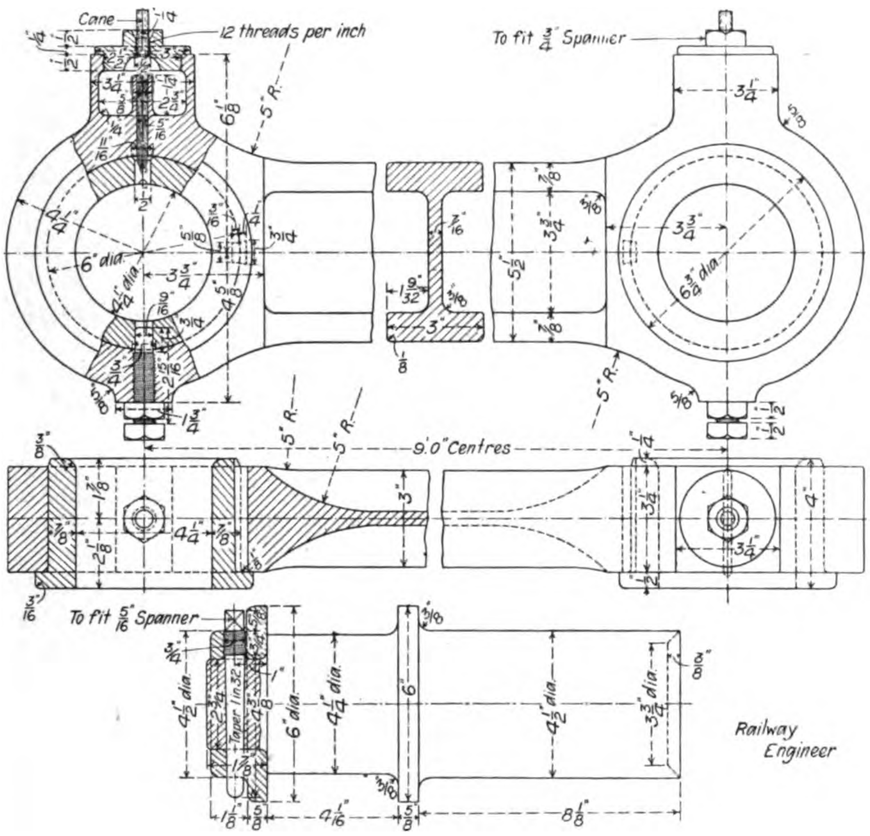


Fig. 42.—Coupling Rod; Great Eastern Railway.

of cast brass and fixed to the brass by means of a flange with four $\frac{1}{2}$in. studs and lock nuts, the joint beng made with a thin leather washer. The cup is $2\frac{3}{4}$in. diam. by $2\frac{3}{8}$in. high inside, closed by a cast brass cap screwed in and having a filling hole in the centre fitted with a cane plug. The feed-hole, which is $\frac{5}{16}$in. diam., is plugged with a worsted trimming as shown, and leads to a round-ended oil trough 1in. by $2\frac{1}{4}$in. along the top of the bearing.

The Small-end is a solid eye fitted with a ring, gun-metal bush, having a bearing 3in. diam. by $3\frac{1}{16}$in. long. The bush is $\frac{3}{8}$in. thick, and is pressed in and secured in its place by a dovetailed key as shown. It is provided with an oil-way $\frac{3}{8}$in. diam., down which the oil drips from a box fitted on to the cross-head.

Coupling Rod, Fig. 42.

This Coupling rod is made of steel. It is 9ft. long between the centres, but this length cannot now be considered as very remarkable, since 10ft. coupling rods are common on North-Western and South-Western engines and 9ft. 9in. on the Caledonian engines. The section of the rod is, however, remarkable, and it is interesting to compare the sections of the North-Western 10ft. rod (fig. 12, *Railway Engineer,* March, '08); the Caledonian 9ft. 9in. rod (fig. 8, *Railway Engineer,* rod (fig. 34, *Railway Engineer,* October, '08); and the Lancs. February, '08); the L., Brighton and S.C., 8ft. 9in. rod (fig. 24, *Railway Engineer,* July, '08); the South-Western 10ft. and Yorks. 8ft. 7in. rod (fig. 37, *Railway Engineer,* November, '08), as showing how widely all these designs differ from each other.

The eyes of the Great Eastern coupling rod are struck with a $4\frac{1}{4}$in. radius and are $3\frac{1}{4}$in. thick. They are fitted with bronze ring bushes $\frac{7}{8}$in. thick, having bearings $4\frac{1}{4}$in. diam. by 4in. long, the journal being $4\frac{1}{16}$in. long. The Bush is flanged at one end. It is pressed in and retained by a $\frac{3}{4}$in. steel set screw, fitted with a lock nut and also by a dovetailed steel key, which is prevented from working out by the flange of the bush at one end and by the collar of the coupling rod pin at the other.

The Oil-cup is solid with the rod, but otherwise is fitted in a precisely similar manner to that on the Big-end above described.

The rod is parallel, the section being uniform. It is $5\frac{1}{2}$in. deep and is milled out to an **I** section, the flanges being 3in. by $\frac{7}{8}$in. and the web $\frac{7}{16}$in. thick. The fillets between the web and the flanges are $\frac{3}{8}$in. radius, and the top and bottom corners are rounded off to a radius of $\frac{1}{8}$in., and the inside corners to a radius of $\frac{1}{16}$in.

The Coupling Rod Pin is of steel. The journal is $4\frac{1}{4}$in. diam by $4\frac{1}{16}$in. It is fitted with a wrought iron washer secured by a tapered steel pin screwed in as shown. It is pressed into the wheel and riveted over.

(*To be Continued*).

Glasgow Central Station Extension.*

The Central Station in Glasgow is the principal station on the Caledonian R. It is a terminal station, and has recently been much altered and extended. During the last decade, many terminal railway stations in this country, as well as in France and America, have had to be reconstructed and enlarged, owing to the universal increase of railway passenger-traffic in great cities; and the Paper is a description of the reconstruction and equipment, on principles based on modern requirements, of the chief terminal station in the City of Glasgow. The Paper deals particularly with the preliminary work of planning and the scheming of the general arrangement, and describes the accommodation and equipment, with no more than passing reference to the structural works.

The station is situated in the heart of the City at or in the vicinity of the main thoroughfares and the River Clyde. It is constructed partly over the river, and over several streets, as well as over the Underground Railway which runs longitudinally under Argyle Street. The original station was opened in 1879; but, as the traffic has been almost constantly increasing, the accommodation has had to be enlarged twice within about 20 years.

The providing of a terminal station in the business centre of the City of Glasgow was a great public benefit. Notwithstanding this, however, the Caledonian Co., besides being under the necessity of purchasing the costly site of the station, were compelled to pay large sums of money to the local authorities for so-called concessions and in the name of way-leave. These payments amounted in the aggregate to no less a sum than £175,000.

Glasgow being the centre of a large industrial district, the traffic in the Central Station is very great. The number of passengers using the station increased by 5,156,465 per annum between 1890 and 1899, in which year the total number was 23,257,006. The traffic was then, however, seriously affected by the competition of the Glasgow Corporation tramways, so that by 1904 the number of passengers had fallen to 20,544,931, again rising, however, in 1906 to 21,874,520. With Corporation tramways constructed outside the city boundaries, the tramway com-

*Abstract of a paper by D. A. Matheson, engineer-in-chief, Caledonian R read before the Institution of Civil Engineers, November, '08.

petition is unfair, although the lessening of suburban traffic in a busy terminal station may, under certain circumstances, be an advantage.

The average number of train movements in the station throughout the year exceeds 1,000 per day. The increase of parcels-traffic has been threefold since 1890. The suitability and capacity of the station was, therefore, quite outgrown, and increase of accommodation became a necessity. Glasgow Central Station is not, however, singular in this, as few, if any, of the original terminal stations of this country have stood the test of time in respect of traffic-working capacity.

The site of the Central Station is a difficult one, by reason of its position relatively to the River Clyde and to adjoining public streets; and, being in the centre of the City, the property which it was necessary to acquire was very costly. This affected the design, it being to some extent governed by the circumstances of environment. In the scheming it was realised that the measure of the accommodation to be provided was the great volume of intermittent traffic and the necessity of being able to deal with many thousand passengers per hour rather than with millions per annum. It was considered essential that there should be separation of the several kinds of traffic. For convenience in working, and with the view to the separation of particular traffics, it was decided to have the longest platforms on the extreme sides of the station, and, so far as practicable, use them for the departure and arrival of main-line trains respectively. The platforms for the shorter-distance and the suburban traffic were placed about the middle of the station. Fortunately, the majority of the trains for workmen run east and west by way of the low-level part of the Central Station, so that the scheme of extension of the Central Station was not influenced by the Cheap Trains Act of 1883, or the shadows of the revived Select Committee on Workmen's Trains, and the recently presented Bill in Parliament to amend the law relating to cheap trains, as under other circumstances it might very seriously have been.

The works were so designed that, in the event of future extension, there should be the minimum undoing of what had been done. The reconstruction had to be carried out so that there was never less accommodation available for the traffic than in the old station, and this was successfully accomplished without harming a single passenger or delaying a single train during the course of the work. The work was carried out partly by administration, and this course was justified by the result.

The station may be described as being a high-level station, the platforms being 24 ft. to 33 ft. above the level of some of the main streets which are crossed. The substructure is therefore a costly work of considerable magnitude. It consists of an extensive bridge over the River Clyde, and masonry arching and steelwork construction over and between the streets. These structures carry the station yard and the lines and platforms of the station proper. The space underneath the lines and platforms provides accommodation for a spacious parcels office and other purposes.

There are altogether thirteen platforms, but the width of the station at the concourse is so narrow that their ends had to be stopped in echelon. The concourse therefore lies obliquely to the lines and platforms instead of at right angles, as is more usual. The lengths of the main traffic-platforms range from 800 ft. to 900 ft., and of the less important from 450 ft. to 610 ft., while the widths vary between 22 and 30 ft.

As a criterion of the increased size of the station, it may be stated that the maximum width has been increased from 210 ft. to 360 ft.; the concourse has been increased in area from 550 sq. yds. to 3,000 sq. yds., the platforms have been increased in aggregate length from 1,530 yds. to 2,910 yds., and in aggregate area from 6,250 sq. yds. to about 14,000 sq. yds.; the parcels-office has been increased in area from 500 sq. yds. to about 6,000 sq. yds.; and the roof of the train-shed has been increased in area from 14,572 sq. yds. to about 35,278 sq. yds. Then, measured in single line, the permanent way in the station and its precincts has been increased from 1¾ mile to 5¼ miles.

It was considered essential that the lines of the station-yard should be as numerous and as long as possible, and that there should be adequate auxiliary siding accommodation. The permanent way of the station-yard is so laid out that there is direct connection between any of the running lines and any of the platform lines, and the lay-out of the running and cross connecting lines is such as to allow of the simultaneous movement of several trains in either direction. As the rails in the station are on a falling gradient towards the concourse, hydraulic buffer-stops have been provided at the end of each line of rails.

A feature of the accommodation is a special platform near the middle of the station, extending in length to about 1,000 ft. and of a width of 33 ft., on which there are two rows of columns for support of the roof. Two rows of columns are considered less obstructive than a single row, having regard to the streams of passengers and the luggage-barrow traffic. The purpose of this special platform is the working of two ordinary trains end on, that is, one in front of the other access to the inner part being obtained by means of a crossover road between the adjacent lines near the middle of the platform. The expediency of this arrangement is doubtful, as the outer part of the platform is a long way from the concourse. The platforms are roofed in to about 86 per cent. of their length. This is a greater proportion than is usual, but the climatic conditions of Glasgow are exceptional. The roofing of the new part of the station, which is about 900 ft. long, is constructed of steel and glass, and the girders being elliptical in form there is pleasing vista in the length. The character of station roofing generally is discussed, and the roofing of Liverpool Street Station is set up as being ideal. The cab-rank is about 1,000 ft. long, and takes up a very important part of the area of the station, perhaps to the detriment of other accommodation. The method of dealing with passengers' luggage in this country necessitates such an arrangement in all British railway stations, whereas in Continental countries cabs are not brought into the main part of the station.

The concourse had to be of specially large area, and it is surrounded with the usual offices and appointments of a railway-station, among the latter being the train-information indicator. This indicator is a feature of the station, and is so placed that passengers can readily ascertain by personal observation all the information they require in regard to trains.

The ever-increasing volume of the parcels-traffic necessitated the provision of extensive premises in the sub-structure of the station at the level of Hope Street directly underneath the passenger-platforms; there is direct communication between it and the platforms by means of a stairway and a series of hoists. This arrangement of the parcels-traffic accommodation has been found so advantageous as to suggest that the parcels-premises attached to all great terminal stations should be specially constructed either above or below relatively to rail-level, provided there is only a single hoist journey, that is a journey up or a journey down. The general accommodation and equipment is extensive and of the most modern character.

An extensive generating-plant is installed in the sub-structure of the station for the generation of electricity for lighting purposes, as well as for driving air-compressing appliances in connection with the working of the points and signals. Steam from the boilers of this installation is also used for the heating of carriages of departing trains and for the heating of the waiting-rooms and other accommodation.

The signalling in connection with the old station was the ordinary manual system; but, after much consideration, it was decided to introduce a system of power working in the extended station. Under the manual system, three signal-boxes were required, but, having regard to the large number of trains to be handled, particularly at the high-pressure period of the day, and the necessity there is for the swiftest possible operation, it was thought desirable to have one signal-box. This necessitated the elimination of the question of restrictive distance in the working of facing points, so that it was essential that there should be other operating agency than that of direct manual labour. It was ascertained that the capitalised value of the loss of efficiency of the station and the approach-lines which would have resulted from working by manual labour in three separate signal-boxes was more than enough to pay for power working.

Investigation having been made—not only in this country, but also in France and America—as to the best system of power working, and experiments also having been carried out locally, it was ultimately decided to adopt the Westinghouse electro-pneumatic system. There are 337 levers and 37 spaces in the interlocking frame, and the installation is said to be one of the largest there is.

The Paper concludes with some reference to the principle in design. The author considers it doubtful if more than a very general principle exists, since so much depends on local circumstances.

He states that the measure of the sufficiency is not so much the area of the train-shed and the extent of the inside accommodation as the capability of the outside accommodation to be truly complementary; and he considers it may be laid down as an established principle in design that fitness and efficiency are governed by the character and extent of the outside accommodation, by which is meant the lines and lay-out of the station yard, the auxiliary sidings, and the approach lines, supplemented by an effective system of signalling.

The accommodation for the comfort and convenience of passengers, and the arrangements for service working inside the station, must also, of course, be carefully considered, particularly

in respect of the relationship in plan.

At the busiest time of the day in the station there should, he urges, be a fixed ratio between the number of passengers and districts and the number of trains, the number of platforms, the number and facilities of the lines in the station-yard, the number of the approach-lines, as well as the extent of the auxiliary siding accommodation. Although the lines of the station-yard and the approach-lines in this catalogue appear in their order to be among the last of the factors of the problem, they are regarded as the first in importance, since they can be described as constituting the main artery of the station anatomy, while relatively the auxiliary siding accommodation is as vital as the heart.

With the essentials determined, the station must be schemed to meet the local and special requirements. The design of a terminal station in a great city will, however, in a measure always be governed by the circumstances of environment if, as there should be, there is due regard to civil engineering economics.

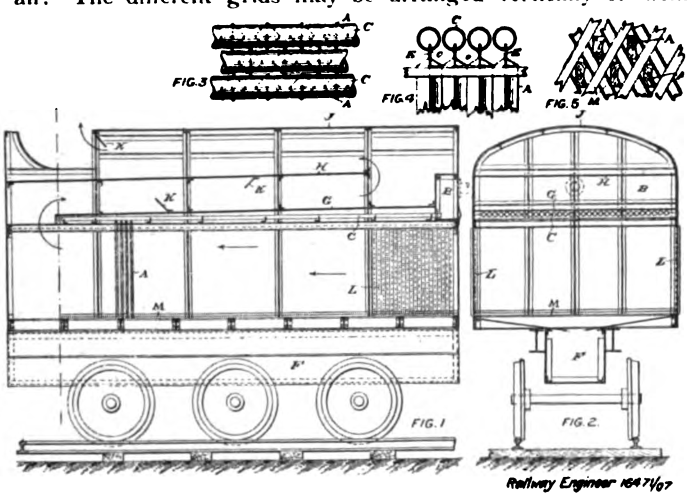
The works were designed and constructed under the direction of the author, with Sir John Wolfe Barry, K.C.B., Past-President Inst.C.E., as Consulting Engineer.

Recent Patents Relating to Railways.

THESE abridgments of recently published specifications are specially compiled for this review by Messrs. Wheatley and Mackenzie, Chartered Patent Agents, 40, Chancery Lane, W.C., from whom copies of specifications can be obtained at an uniform price of 8*d*. each.

Condensing Locomotive Engines. *16,471. 18th July, 1907. J. D. Crighton, The Klein Engineering Co., Ltd., 94, Market Street, Manchester.*

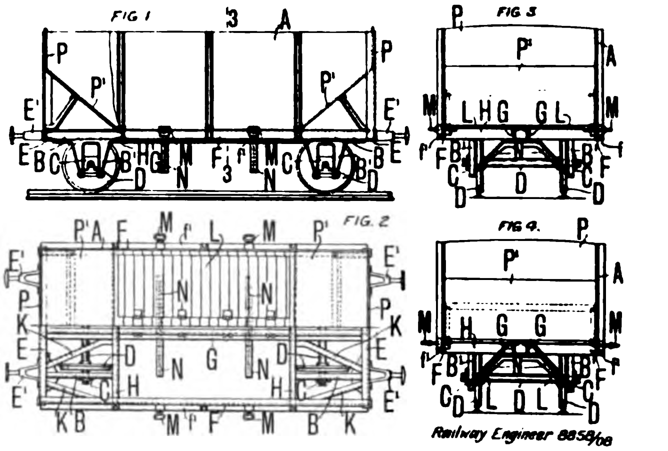
A condensing water cooler of the drip type is, according to this invention, mounted upon a truck provided with inlets and outlets for air which passes through the cooler when the truck is running. In the arrangement shown wooden laths A are arranged close together across the truck and practically throughout its length so that the air current set up by the movement of the truck and indicated by the arrows may pass between and amongst them. The laths form a series of grids or grates across the truck, being so relatively disposed that there are no or only slight straight passages through or between them for the passage of air. The different grids may be arranged vertically or with



either their lower or higher ends in advance. With the higher ends in advance any water which would tend to drop off or through a frame when the truck is stationary would be carried back by the air current and confined to its frame when the truck is running. With the lower ends advanced the downward flow of water would be checked or retarded by the air current. The water from the condenser is led through a chamber B to a series of perforated distributing pipes or troughs C extending above the cooling laths or equivalents A, and is delivered for cooling to the upper ends of the frame of laths or to the upper ends of the laths. In order to separate any water which may be in suspension in the cooling air the air passes under the distributing pipes to the rear of the truck, then upwards and returns to or towards the front end of the truck over the pipes or a floor G placed above such pipes and beneath an approximately horizontal partition H which extends to nearly the front of the truck, and then again rises and returns towards or to the rear end of the truck above the horizontal partition H and beneath the roof J of the truck. It then emerges through a suitable outlet into the atmosphere. At the various turns and at the outlet the air encounters acutely disposed or other baffle plates K which may be attached to the horizontal floors or partitions or to the roof, and which separate or retain any water in suspension. (*Accepted 20th July, 1908.*)

Waggons. *8,858. 23rd April, 1908. Date claimed, 17th June, 1907. Fried Krupp Aktiengesellschaft, Essen, Germany.*

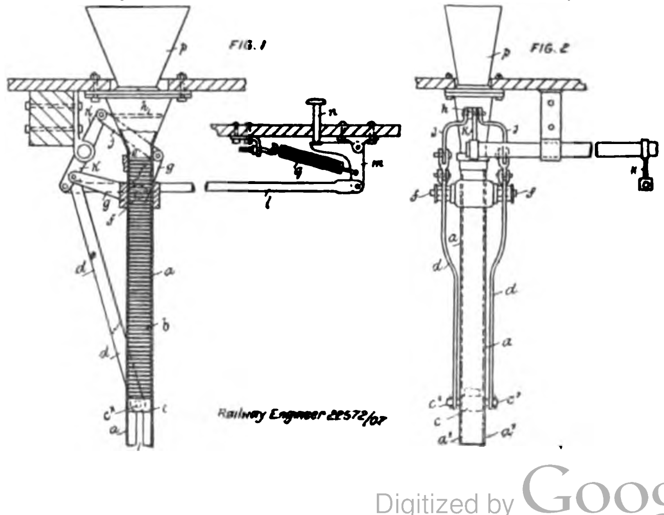
According to this invention, goods waggons, with arrangements for self-discharging, have longitudinal girders F constructed as main girders of the underframe and end girders E carrying the buffers. In the middle of the frame E, F is placed a traction girder consisting of two **Z** shaped longitudinal girders G, and parallel to the end transverse girders E are two transverse girders H. Built in between the end transverse girders E and the transverse girders H are four axle holder carriers B, which run parallel to the longitudinal girders F and G, and are preferably made in one piece with the axle holders B^1. In addition to this, two diagonal struts K are placed between the transverse girders E and H for each buffer E^1, and transmit the shocks taken up by the buffers E^1 to the longitudinal girders



F and G. The longitudinal walls of the waggon body A stand at right angles to the plane of the underframe, while the front walls each consist of a vertically directed portion P and a sloping portion P^1. The inclination of the portion P^1 of the front walls P, P^1 corresponds to the gradient of the material to be loaded into the waggon. In the areas of the underframe bounded, on the one hand, by the longitudinal girders F and the traction girder G, and on the other hand by the transverse girders H, the bottom of the waggon body is formed by two horizontally lying discharging flaps L, which are pivoted to the traction girder G. These bottom flaps L may be held in their closed position by bolts M placed on the side longitudinal girders F, and when in their open position bear against stop bars N which are placed on the under-side of the traction girders G. The transverse girders H are placed as close as possible to the sets of wheels D, so as to enable the bottom flaps to be made as large as they possibly can be. The longitudinal girders F are of **Z** shape in transverse section, and are so built in that the lower flange f^1 of each girder points outwards; this ensures that the effective outlet opening of the bottom flaps L is as large as possible. (*Accepted 9th July, 1908.*)

Sanding Apparatus. *22,572. 14th October, 1907. M. Cummins, 518, Stretford Road, Manchester.*

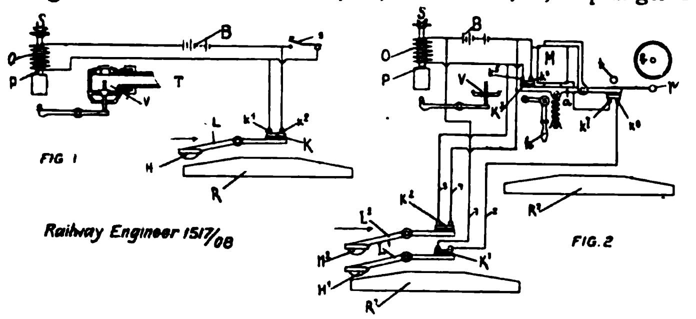
In order to prevent the sand tube *a* being choked by an accu-



mulation of wet sand caused by water being thrown up the mouth of the tube in wet weather, the tube is lined with a coil spring *b* that is capable of compression, and in the bottom of the tube is placed a hollow plunger *c* that has a stud c^x projecting through a slot a^x on each side of the tube, and a rod *d* connected to each of said studs. The lower portion of the plunger *c* is of the same diameter as the internal diameter of the tube *a*, but the upper portion of the plunger is of less diameter, so that the bottom of the coil spring *b* will rest on the top edge of the bottom and larger portion of the plunger, and the top end of the spring abuts on a fixed shoulder at *e* inside the tube. A bell crank lever *g* is fitted on each of the studs *f*, one end of each bell crank lever being connected to one of the rods *d*, and the other end of each bell crank lever connected by a lever *j* to the valve *h* of the sand box *p*, and also to one end of a pivotted lever *k*, whose opposite end is connected by a rod *l* to one end of a bell crank lever *m* that is under the footplate, the foot pedal *n* resting on the opposite end of the bell crank lever *m*. When the valve *h* is opened either electrically or by the foot pedal *n* actuating the lever *k*, the plunger *c* is forced down to the bottom of the tube *a* by the lever *d*, the expansion of the spring *b* ejecting any wet sand that may have lodged therein, and the expansion of the spring will also prevent any sand collecting on the inside of the tube. When the pedal *n* is released the spring *q* will cause the valve *h* to close and draw the block *c* within the tube *a* and compress the spring *b*. (*Accepted 30th July*, 1908.)

Automatic Apparatus for Stopping Railway and Tramway Vehicles. *1517. 22nd January, 1908. Siemens Brothers Dynamo Works, Ltd., York Mansion, York Street, Westminster, and F. Lydall, 16, Bedford Gardens, Kensington.*

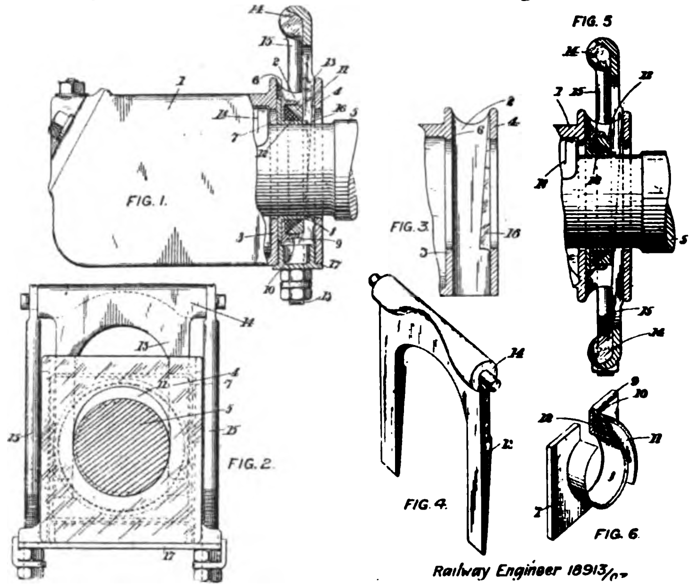
This invention relates to means for protecting railway or tramway vehicles in case of failure by the driver due to death, sudden ilness or any other cause, and consists in mounting devices on the track, and co-operating apparatus on the train, adapted to cut off the supply of current to the motors and apply the brakes unless the driver operates the apparatus on the train to prevent this result when the train passes the track devices. In its simplest form the invention comprises a ramp R fixed to the sleepers and a shoe H carried by a lever L on the vehicle, an insulated contact piece K arranged to connect contacts k^1, k^2, switches *s*, S, a plunger P



held up by a solenoid O and a valve V through which the train pipe can be put in communication with the atmosphere. When the shoe H passes over a ramp the circuit of the driving motors will be broken at the switch S and the brakes applied by the falling of the plunger P unless the driver keeps closed the local circuit by means of the switch *s* while the circuit is opened at K. In order to warn the driver on his approaching a ramp a second ramp and an extra shoe with suitable connections are provided for ringing a bell, Fig. 2. In this case a handle *h* must be operated by the driver to replace an armature *a* after the warning has been given to prevent the train being stopped by the second ramp. A further form of the apparatus is described in which means are provided to prevent the driver from fastening his handle in such a position that the armature *a* would not fall. (*Accepted 27th August*, 1908.)

Axle-Boxes. *18,913. 22nd August, 1907. E. Peckham, Queen Anne's Chambers, Westminster, and C. B. Miller, The Magnolia Anti-Friction Metal Co., 49, Queen Victoria Street, London.*

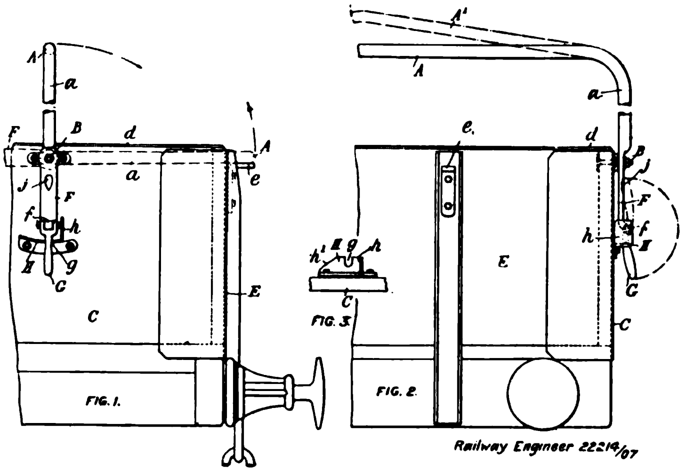
This journal box, which is intended for the axles of railway and tramway vehicles, comprises a casing 1, having at its rear end a rectangular chamber 2. The packing is shaped to fit the chamber so as to prevent turning with the axle, and consists of a formed packing sheet 7, preferably of a square piece of leather, provided with an opening for the axle, the edges of the opening being turned out to form a collar 8 which encircles the axle. A square or rectangular metal plate 9 is also provided, having an annular recess 10, in which is seated split wedge-shaped rings 11 and 12 of rubber wood or other suitable material. The plate 9 is slipped over the collar 8 and is capable of forcing the leather packing 7 against the surface 6 of the partition 3, and thus preventing oil from escaping. Instead of applying pressure direct against the plate 9 the pressure is applied to the outer ring composed either of wood, metal or other hard substance. This ring is forced against the ring 12, which is preferably made of softer material and provided with an opening to receive the axle over the lining collar 8. The



opening may be slightly tapered and the thickness of the leather or other collar 8 oppositely tapered in order that pressure may be applied to close and force the collar around the axle. The packing ring 11 bears against the ring 12 and also against the perpendicular side of a wedge or wedges 13, which bear against and slide on the outer wall of the chamber 4. When two wedges are employed one is dropped into place over the axle through the open top of the chamber, and the other wedge is inserted from below. The wedges are forked or divided to straddle the axle, and are each provided with horns 14, which protrude above and below the journal box outwardly, the horns being connected together by bolts 15 or other adjustable tightening devices. When the wedges are drawn together and slide over each other the packing rings and packing are forced into closer contact with the axle and against surface 6 of the partition 3, and thus prevent the escape of any oil from the box. (*Accepted 20th August*, 1908.)

Tarpaulin Supports for Wagons. *22,214. 8th October, 1907. E. J. Hill, 11, Victoria Street, Westminster.*

Transverse supports A are provided and pivoted at B to the sides of the wagon. When folded down out of use, as indicated by the dotted lines in Figure 1, the transversely extending portion or cross bar A of the support will preferably just clear the outside end E of the wagon, in which position it is sustained by any convenient means, such, for example, as a pair of stops *e* on the ends



of the wagon against which the bar A then rests. Or, the stops might be fixed to the sides C of the waggon so as to engage the portions *a* of the support. To enable the supports to be more readily manipulated from the side of the track, the extremities of each are prolonged, as at F, beyond their pivotal connection B

with the sides C of the wagon so as to form hand-levers by means of which the supports can be easily lifted from their resting to their operative position or *vice versa*. Preferably the handle portion G of each of these hand-levers would be jointed, as at *f*, to the lever F, so as to be capable of angular movement in the common plane of both end portions *a* of the support in order to enable the handle G to be engaged with and disengaged from a notch *g* in a segmental rack H attached to the side C of the wagon concentrically with the pivot B, about which the support itself is movable, so that the support may be locked in the erect position or may have the inclination of its end portions adjusted in accordance with the height at which it is required to support the cover. The rack H is provided at one end with a stop *h* adapted, by engaging the lever F, to prevent the support passing beyond the erect position. (*Accepted 13th August*, 1908.)

Doors for Wagons. *17,990. 7th August, 1907. W. R. Preston, of J. Stone and Co., Ltd., Deptford, and H. S. Wainwright, Alfred House, Ashford, Kent.*

According to this invention ordinary doors, whole side doors and bottom doors of trucks, or the side flap doors of horse boxes and cattle trucks and other structures are provided with a sliding and partially revoluble stanchion adapted to serve the two-fold purpose of holding the door in the closed position when in the lowest or extreme position in one direction, and when raised or pushed in the other direction, to come into a guide and into contact with a spring or buffer which is adapted to be compressed as the door swings outwards and downwards, or merely downwards, as the

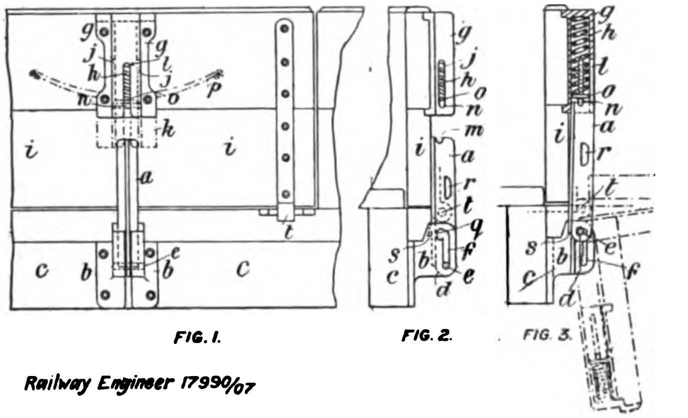


FIG. 1. FIG. 2. FIG. 3.

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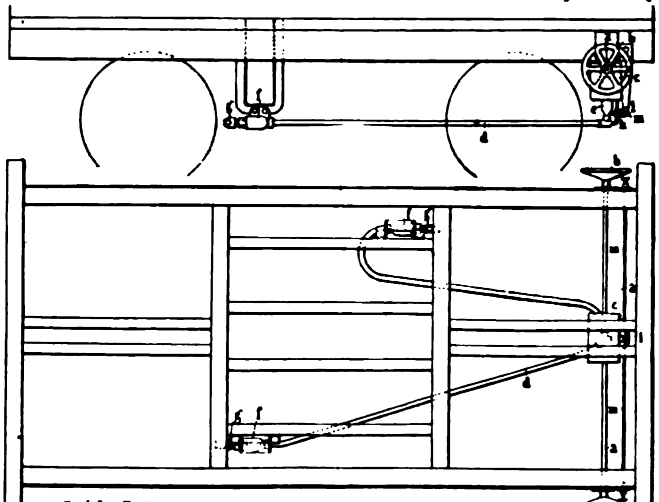
case may be. The stanchion *a* is adapted to slide and pivot in a bracket *b*, *b* fixed to the underframe *c* of the truck. Near the bottom of the stanchion is fixed a pivot *e*, which is adapted to slide in the slots or recesses *f* in the bracket *b*, *b* in such manner that the stanchion may normally rest and be guided or rigidly held in the bracket, that is to say, when the pivot *e* rests at the bottom of the slots *f*, but that when the stanchion *a* is raised or withdrawn from the bracket it may be partially rotated or swung on the pin or pivot *e* at the extreme end of the slots. In order that the stanchion *a* may operate on the spring *h*, a bracket or guide *g* containing the spring is preferably mounted on the side of the door *i* into which guide the stanchion enters, and this guide may be so arranged as only to receive the end of the stanchion when the door has rotated a certain distance, or the bracket may be extended as indicated at *k* in dotted lines, fig. 1, so that the stanchion may enter the guide before the movement of the door begins to take place. The guide is preferably slotted at *l* to permit of the revolution of the door independently of the stanchion sliding therein and abutting with its recess *m* against a bearing surface or knife edge on a cross piece *n* at the bottom of a piston or slide *o* adapted to move in the guide *g*, the cross piece *n* being adapted to receive the end of the stanchion which is shaped to correspond. The cross piece *n* projects into and is guided in a vertical slot *j* on each side of the guide *g*. The spring *h* abuts against the slide *o*, and this spring may either be of the helical, leaf or other suitable type. If the spring be of the leaf type the guide is preferably provided with larger slots on each side so as to permit the spring to pass right through, and the dotted lines *p* indicate the position a laminated spring would occupy. (*Accepted 6th August*, 1908.)

Liquid Brakes. *21,749. 2nd October, 1907. W. Redpath, 41, Lindley Street, York.*

This invention has reference to brakes in which liquid is forced from a pump into ram cylinders connected with the brake shoes. A shaft *a*, mounted in suitable bearings and provided with hand wheels *b*, by which it can be readily rotated, is adapted to operate a force pump within a pump chamber *c*, suitably suspended beneath the vehicle. Pipes *d* connect the force pump *e*, with cylinders *f*, fitted with rams *g*, the ends of which are adapted to be connected to the brake blocks. A bye-pass *h* connects the pipe or pipes *d*, or the delivery side of the pump to the interior of the pump chamber *c*, and this bye-pass pipe is fitted with a release valve *i*. When the brakes are to be applied either of the hand wheels *b* is rotated and the shaft *a* operates the force pump *e*, which forces liquid from the chamber *e* into the cylinders *f*. When the brakes are to be released the release valve *i* is opened by a



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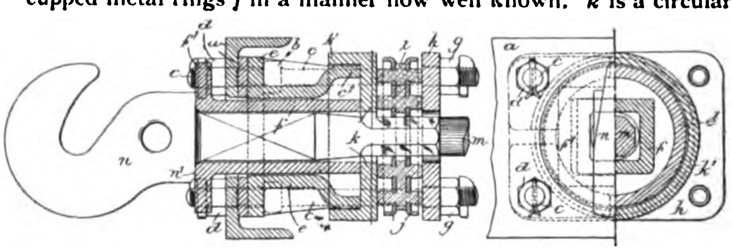
lever *m*, so that the pressure of the liquid in pipes *d* and cylinders *f* is at once relieved. When the invention is to be applied to a passenger brake van which is fitted with existing brake mechanism, for instance, of the Westinghouse system, the hydraulic ram *f* is connected to the existing rocking lever *l*. The end of the ram *f* is preferably formed as a yoke *p*, to which two links *q* are connected, the ends of the links being slotted as at *s* to receive a pin *t* passing through the rocking lever *l*, which is connected by a pin *u* to the slotted end *v* of the piston rod of the Westinghouse cylinder *w*. By this arrangement either brake system may be used without interfering with the working of the other. The invention can also be applied to vehicles fitted with the vacuum brake system. (*Accepted 6th August*, 1908.)

Draw Gear. *9692. 4th May, 1908. A. Spencer, 77, Cannon Street, London.*

This invention relates to continuous draw gear for railway vehicles in which draw bar cradles are embodied, and has for its object to provide means whereby shock hitherto occasioned by engagement of the draw hook shoulders with the headstocks is avoided. To the inner side of the headstock *a* is secured by collars *b* on tie bolts *c* and nuts *d* a tubular guide *e* which is of square shape in exterior and interior cross section at e^1 and adapted to receive a draw bar sleeve *f* which is also of square shape in exterior and interior cross section. The bolts *c* serve with the aid of nuts *g* to tie to the headstock *a* a buffing plate *h* against which bears a spring, conveniently constituted of concentric india-rubber rings *i* separated by cupped metal rings *j* in a manner now well known. *k* is a circular



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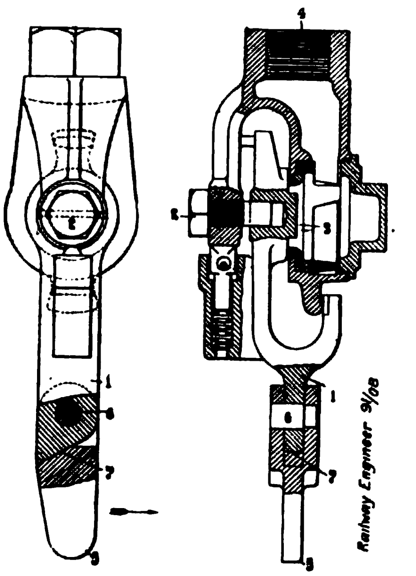
spring compressing a plate, shown as a cupped plate, against the inner side of which the spring bears and against the outer side of which the sleeve *f* is arranged to bear. The flange k^1 of the plate encircles the exterior circular portion e^2 of the stationary guide *e* which serves as a stop to limit the outward movement of the plate. The draw bar *m* carrying the draw hook *n* passes through the sleeve *f*, the plate *k*, the spring *i*, *j* and the buffing plate *h* and is coupled in the usual way through a cradle to the draw bar at the other end of the vehicle, the shoulder n^1 of the draw hook *n* engaging the flanged extremity f^1 of the sleeve *f*, which, as shown, is normally out of contact with the headstock *a*. The arrangement is such that when a pull is applied to the draw bar at one end of the vehicle the tractive force is transmitted through the shoulder n^1

of the draw hook n at the other end of the vehicle to the adjacent sleeve f, which therefore causes the plate k to advance and compress the spring $i—j$ against the buffing plate h. In this way the vehicle will not respond to the pull until the compression of the spring $i—j$ overcomes the inertia of the vehicle so that a sudden start is avoided and no shock is experienced by engagement of the draw bar with the headstock. With existing arrangements of continuous draw gear the draw bar cradle springs alone are relied on to absorb starting and stopping shocks, whereas with the present improved gear the cradle springs are employed exclusively for absorbing shocks on the draw gear caused by movement of the train. (*Accepted 6th August*, 1908.)

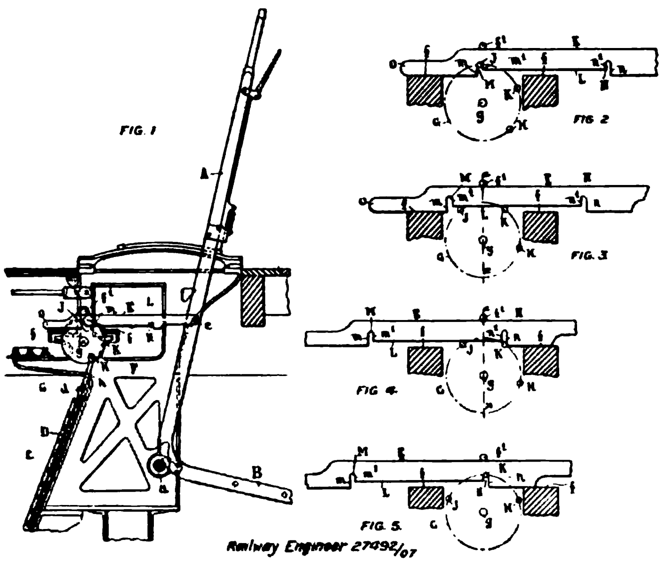
Train-Pipe Trip-Valve. *91. 1st January, 1908 (Patent of addition to No. 12,262. 29th May, 1903). J. W. Cloud, 82, York Road, King's Cross, London.*



This invention relates to a train-pipe valve provided with a depending arm or lever adapted to be operated by a tripping device on the track to open the valve and cause the brake to be applied. According to the present improvement the lever is so constructed that the trip will be operative when the vehicle or train is moving in one direction only, so that the vehicle can be shunted back over a tripping device without the valve being opened. For this purpose the lever is made in two parts 1, 5 connected by a knuckle joint or hinge, formed by slotting the upper extremities of the part 5 to receive the lower extremity of the part 1. (*Accepted 13th August*, 1908.)

Interlocking Apparatus. *27,492. 12th December, 1907. E. R. F. Hallam, 328, Hither Green Lane, Lewisham, and W. R. Sykes, 26, Voltaire Road, Clapham.*

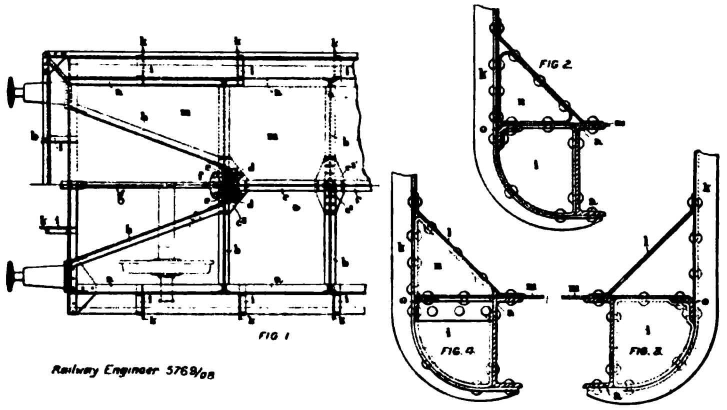
This invention relates to mechanism for operating the interlocking tappets in connection with the hand levers of points, or signals, in which a cam bar pivoted to the hand lever and having a notch at each end is in engagement with crank pins turning about a common centre with a crank coupled to the tappets. To the lever A is pivoted as at e the horizontal cam-bar E which receives longi-



tudinal to-and-fro motion from the hand lever, the bar when at its extreme positions alternatively resting upon one or other of a pair of guides $f\ f$ provided on the lever frame F. Beneath the cam-bar E, at a point g midway between the supports $f\ f$, a disc G is so mounted on the frame as to be rotatable in the plane of motion of the lever A and parallel and close alongside of the plane wherein the cam-bar reciprocates. This disc G carries three crank-pins H, J and K, whereof H is permanently coupled by means of a link h to an eye d on the locking tappet D. The crank pins J and K are equidistant from the centre g of the disc G and are adapted to be engaged by the cam-bar E in such manner that, during both of the terminal portions of the stroke of the lever A, the disc G will be rotated sufficiently to cause the tappet D to slide in its guides the distance required for effecting the locking or unlocking operation relatively to the locking bolts in the frame C, whereas, during the intervening or middle portion of the stroke of the lever A, rotation of the disc G and consequent movement of the tappet D will be positively prevented. For this purpose the lower edge of the bar E has two notches M and N separated by a straight portion L whose length exceeds the distance between the crank pins J and K by an amount corresponding to the extent of the lost motion to be permitted between the lever A and tappet D, that is to say, corresponding to the excess of length of the effective stroke of the lever over the total movement of the tappet in either direction. The notches M, N, which are adapted to take over and engage with the respective crank pins J, K, are perpendicular to the lower edge of the bar, and are deeper at their outer sides m, n, than at their inner sides $m^1\ n^1$, the length of the latter being limited by their intersection with the middle portion L of the edge of the bar, which is maintained at such a distance from the centre e of the disc, relatively to the distance apart of the crank pins J. K, that during the middle portion of the stroke of the bar E both crank pins will be simultaneously in contact with the edge L. The cam-bar is normally retained in contact with the guides $f\ f$ by means of a removable stationary roller f^1, and is provided with a prolongation O forming a handle whereby on the removal of this roller the bar can be lifted clear of the pins M, N. (*Accepted 27th August*, 1908.)

Underframes. *5769. 14th March, 1908. G. H. Sheffield, 15, New Bridge Street, Newcastle-on-Tyne, and J. D. Twinberrow, 1, Woodside, Hexham.*

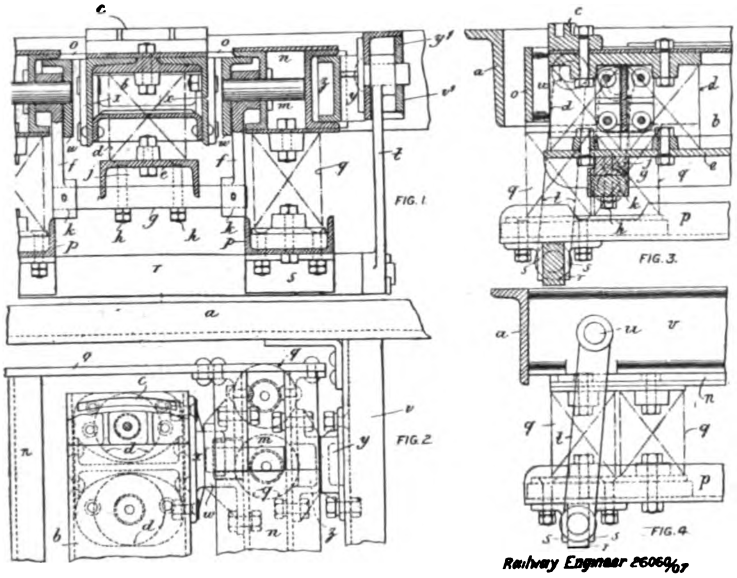
Two sole-bars or main longitudinals, a, are connected by a number of continuous cross bearers, b, placed at suitable distances apart so as to transfer the load more directly to the sole-bars, a, only a single inner longitudinal, c, being employed in addition to the sole-bars. The longitudinal, c, is made up in short lengths joined to each cross bearer, b, by brackets c^1 and tie plates c^2, although in some cases it may be arranged at a lower level to pass underneath the cross bearer. Draw springs d, are arranged in pairs to abut



on the main cross bearer, one spring or nest of springs being on each side of the central member c. Each spring is fitted with a short draw-bar, e, connected to an equalising lever f, to the centre of which a main draw-bar, g, is attached. The headstock is supported against buffing shocks by means of the sole-bars, a, and diagonals, h, the ends of the diagonals being brought close to the middle point of the main cross bearer where it is supported by the middle longitudinal, c. In this way a very strong joint is obtained at the junction of the diagonal, h, the end of the longitudinal, c, and the cross bearer, b, which are all tied by the plate c^2. In order to prevent outward deflection of the stanchions when under load, the attachment at the foot of each stanchion should be rigid, and for this purpose a flanged bracket, i, is adapted to receive the foot of each stanchion, k, and to connect it to the outer angle of the sole-bar, a. Further, rigidity may be obtained by means of an inclined plate, l, adapted to slope upwards from the top flange of the sole-bar, a, to the side at some distance above the lever of the floor, m. This inclined plate also facilitates the unloading of bulk freight by shovel, prevents corrosion in corners and avoids the tendency of bagged goods to burst when crushed into a square corner. An additional flanged bracket, n, may sometimes be fitted beneath the sloping plate, l, adjacent to each stanchion, k, to which the bracket, n, is attached. The usual continuous longitudinal outer angle may be dispensed with except

at the positions where the doors are to be fitted, for instance, as shown in Figures 2 to 4, a short outer angle, *o*, may be retained between two of the brackets to which it is attached so as to form a bearing piece for the purpose of attaching the hinges of each door. The depth and width of the side and floor plates may thus be shortened on either side of the doorway or on either side of each doorway when more than one is provided, the sloping plate, *l*, acting as a distance piece and filling the void between the shortened side and floor plate. (*Accepted 3rd September,* 1908.)

Bogies. *26,060. 25th November, 1907. A. Spencer, 77, Cannon Street, London.* The bolster *b* is supported, through springs indicated diagrammatically at *d*, upon a spring plank *e* that is carried by links *f* through bars *g* connected to the plank *e* by bolts *h*; wooden blocks, *j*, *j*, being interposed between the bars *g* and bolster *e*. The bars *g* are formed with trunnion-like ends *k* each mounted in the lower end of a link *f*. At their upper ends the pair of links *f* at each side are mounted to turn on pins *m* which are carried by an inter-



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mediate bolster *n*. Two intermediate bolsters *n*, which are connected at their ends by plates *o*, are each supported by a spring plank *p* through springs indicated diagrammatically at *q*. The two spring planks *p* rest on longitudinal bars *r* that are prevented from lateral movement relatively to the spring planks by brackets *s*, and whose ends, which are turned to form trunnions, are supported in the lower ends of links *t* that at their upper ends are pivoted to pins *u* carried by the transverse members *v* of the bogie frame. The inner ends of the pins *m* are each supported in a bracket *w* arranged to form a rubbing block that works against a corresponding rubbing block *x* fixed to the main bolster *b*. The pins *u* of the links *t* are each supported at one end by the corresponding cross member *v* and at its other end by a bracket v^1 secured to the cross member *v*. (*Accepted 3rd September,* 1908.)

COMPLETE SPECIFICATIONS ACCEPTED.

1907.

17990. Fall-down doors of railway trucks, horse boxes, cattle trucks, and other structures. Preston and Wainwright.
18258. Means for securing doors or flaps of railway trucks, horse boxes, or the like. Preston and Wainwright.
21749. Liquid brake for railway vehicles. Redpath.
22757. Bearings, more particularly applicable to the axle-boxes of railway vehicles. Preston (Fabe).
24242. Brakes for railway wagons and similar vehicles. Coles.
26254. Ball bearings, especially suitable for bogie or sub-tracks of railway and tramway vehicles. Walker.
18527. Railway signalling apparatus. Neale.
19264. Means for locking railway carriage doors. Herd and Esplen.
19752. Arches of locomotive furnaces and the like, and bricks employed therein. Roberts and Birkett.
21245. Apparatus for coupling railway wagons and the like. Pollock and Mallinson.
21851. Locomotive boiler with increased heating surface. Kaczynski, Rudnicki and De Sosnowski.
22214. Supports for the tarpaulin and like coverings of open railway wagons. Hill.
23843. Supports for the tarpaulin and like covers of wagons. Parker.
16429. Rails for tramways and the like. Burbey and Kersley.
18913. Axle journal boxes. Peckham and Miller.
19217. Brakes for railway vehicles. Hopley.
21413. Means of controlling the locks of railway carriages, strong rooms, and the like. Taylor and James.
22736. Air brake systems. British Thomson Houston Co. (General Electric Co.).
22861. Automatic couplings for railway and other vehicles. Coles.
24217. Single rail railways. Constantinescu.
24640. Railway vehicle axle-boxes. Atherton.
25454. Means for lubricating the pins of cranks or similar moving parts of locomotive or stationary engines, and the like. Morton.
18764. Railway signalling apparatus. Leader.
19038. Fish-plates and fastenings for railway rail joints. Robinson.
25410. Electric track circuits for railway signalling. Holt and Wallis.
26948. Indicating in compartments of railway carriages the stopping-places of the train. Wilson.
27492. Interlocking apparatus for hand levers for railway points, signals, and the like. Hallam and Sykes.
19198. Spark-killing device for locomotives. Karthaus and Simon.
19266. Ventilators for railway carriages and similar uses. Walker.
19847. Formation and arrangement of railways and tracks for purposes of amusement. Martyne.
20156. Detonating signals for railways. Illidge.
26060. Bogies for railway and the like vehicles. Spencer.
27278. Automatic signalling and stopping apparatus for trains on railways furnished or not with the block system. Maglietta.

1908.

5769. Underframes of railway vehicles. Sheffield and Twinberrow.
14096. Train-operated mechanism for opening and closing doors. Robertson.
1517. Apparatus on railway or tramway vehicles for giving warning and for stopping the same in case of failure of the driver. Siemens Bros., Dynamo Works, Ltd., and Lydall.
1606. Railway signalling means. Marshall and Penman.
5016. Apparatus for bonding rails and similar conductors. Harrison (Electric Railway Improvement Co.).
5702. Driving means for automobiles, locomotive engines, stationary engines, and the like. Reichel.
6749. Railway rail joint. Sevcik.
12333. Railway sleepers of armoured concrete and the like. Cook.
14068. Railway rail fastenings. Olds.
33. Braking apparatus for tramway vehicles. Maunder, Thompson and Mitchell.
1721. Operating mechanism for railway and tramway points and switches. Allen.
8800. Railway signalling apparatus. Racot, Renaud and Lanoe.
11950. Locks for railway carriage doors and the like. Schaller.
12679. Ventilators chiefly intended for use in railway carriages. McLaren.
91. Fluid pressure brakes for railway vehicles and the like. Cloud.
3352. Switches and crossings for compound gauge railways. Brennan.
6181. Railway signalling. Bock.
5111. Apparatus for placing fog signals on railway lines. Clausen.
6122. Railway dumping cars. Goodwin.
9692. Railway vehicle draw gear. Spencer.
14094. Metal keys or wedges for use in securing rails to railway sleepers. Jones.

Official Reports on Recent Accidents.

At **Cornbrook West Junction, Cheshire Lines.** *On 15th May. Lt.-Col. E. Druitt, R.E., reports that:—*

The engine, tender, and train forming the 11.5 a.m. passenger train (Sheffield to Manchester Central) were derailed. One passenger complained of being badly shaken.

The train consisted of a 4-4-0 engine, tender, fitted with the steam brake, and 3 vehicles weighing respectively 31¼ tons 22 tons 17 cwt. and 22 tons 3¼ cwt.

There are two pairs of main lines between Cornbrook West Junction and Manchester Central Station. The up lines to Manchester are on the north side of their respective down lines. These pairs of lines are known as the "A" route and "B" route main lines. The "B" route are on the north of the "A" route lines.

At a point 40 yards west of the signal-box in the "A" route is a double junction leading off to the right for trains to the Manchester S. Junction and Altrincham R., and 10 yards beyond the junction or 50 yards west of the signal-box is another double junction between the "A" route and "B" route lines, the facing points in each case being in the up line of the "A" route. It was at these latter facing points that the first marks of the derailment were found. In this case the up line leads off to the left. Between the "A" and "B" route pairs of lines is a middle road for empty carriage trains, thus after leaving the up line of the "A" route to get to the up line of the "B" route a train has to cross the middle road and the down line of the "B" route. The total length of the junction crossing from the facing points in the up line of "A" route to the trailing points in the up line of "B" route is 136 yards.

At the second pair of facing points, where the crossing to the up "B" line commences, the curvature beginning at the heel of the facing

switches is as follows:—Left hand, 15 ch., 50 ft.; left hand, 18 ch., 80 ft.; tangent, straight, 120 ft.; right hand, 15 ch., 130 ft.

There is a speed restriction of 20 miles an hour, the wording of the Appendix to the Working Time Table being "Cornbrook West Junction—To or from Old Trafford and Oxford Road, 20 miles an hour." There is also a speed board placed alongside the facing points with the following wording, viz.:—"Speed for Junction not to exceed 20 miles per hour."

The train was turned at Cornbrook West Junction through the crossing leading from the up line of the "A" route to the up line of the "B" route. The evidence of the men on the engine is that the first sign of anything being wrong was the tender suddenly leaving the rails at the crossing of the down line of the "B" route. The guard also felt nothing out of the ordinary until he saw the tender jumping at this crossing, and the carriages did not leave the rails until they had reached the heel of the trailing points in the up "B" route road. The driver brought the train to a stand in a distance of 125 yards from the centre of the crossing of the up "B" route road. On examination of the permanent way it was evident that at least one pair of wheels had mounted the rails at the facing points in the up "A" route line which lead across to the up "B" route line.

Judging by the damage done to the permanent way and to the flanges of the tender wheels, and by the evidence of the train men, it would appear that in all probability the leading right-hand tender wheel mounted the right-hand rail where it struck the facing point of the switch rail, and that the leading pair of tender wheels only were off the road from the first heel chair to the crossing of the down "B" road, and that the

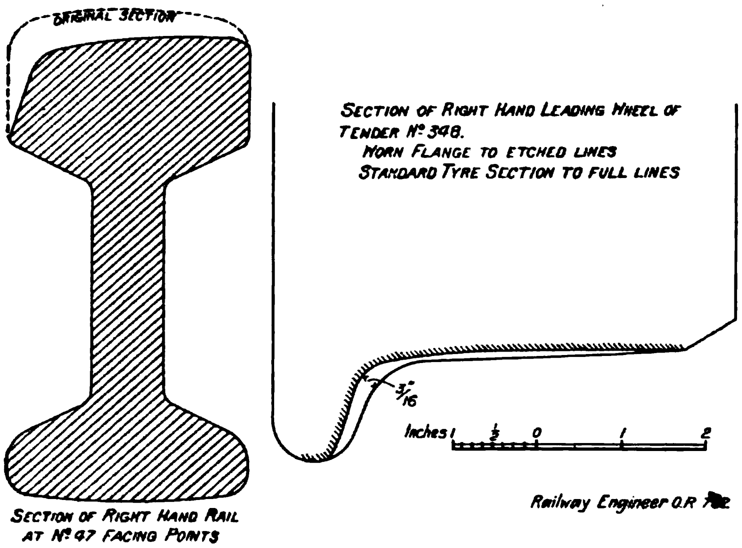

Fig. 1.

carriages did not leave the rails until they reached the up "B" road.

The right-hand rail between the two sets of facing points was very badly worn, the head on the inside being ground away to a shape which corresponded almost exactly to the worn flange of the right-hand leading tender wheel. The weight of this rail was originally 100 lbs. per yard and it had been laid down in June, 1903, nearly five years ago, Fig. 1. The road was half-inch wide to gauge at the facing points, mostly due to the wearing of the rail, as the gauge is left slightly slack on purpose. The head of the left-hand rail between the two sets of facing points was distorted so as to widen the head, showing there had been a heavy wear and longitudinal slipping on the top of the rail.

The tender was last in the shops at Derby in September, 1907, and the last turning of the tyres was done in November, 1906. It has a fixed wheel base of 13 ft., the wheels are 4 ft. 2 in. diam., and the weights carried on the three axles when the tender is loaded are 13¾ tons, 12 tons 16¾ cwt. and 13 tons 16½ cwt.

The length between the trailing wheels of the engine and leading tender wheel is 9ft. 0½in. The flange and tread of the right-hand leading wheel were very much cut about and indented, the other flanges and treads less so. All tyres were worn, the right-hand ones more than the left-hand ones, and the right leading one especially so. The maximum wear of this one at the foot of the flange was $\frac{5}{16}$ inch, and at the point of the flange ⅛ inch. Although the flange was not worn so sharp as to be vertical, yet an edge had commenced to form on the inside lowest point of the flange, and this edge was burred over, showing that this part of the flange had been in contact with the side of the rails. Also the lowest part of the inside of the flange for a depth of $\frac{3}{16}$ inch was worn and polished, showing that there had been binding between that part of the flange and the side rails, fig. 2. The right leading flange could not have got into the condition as regards the formation of the edge on the lowest point of the flange, and the polished state of the lowest ⅜in. of it, in one day.

The speed of trains according to regulation should not exceed 20 miles an hour when passing Cornbrook Junction. The driver put his speed at 15 to 20 miles an hour, and the guard at 20 miles an hour, the usual rate. The signalman considered the speed as 20 to 25 miles an hour. The up "A" route line approaches Cornbrook Junction on a left-hand curve of 60 chains radius, and at the first set of facing points leading to the Manchester South Junction and Altrincham line the radius of the lay out is 20 chains radius also to the left, and at the second set of facing points leading across to the up "B" route the radius of the lay out is 15 chains radius still to the left. But although the radius of the lay out curves are as given above, the actual divergence from the tangent of the two sets of switches is equivalent to that on a curve of much sharper radius. No superelevation of the outer rail can be given at either turnout, and the speed limit on junction crossings of this description should not be as high as 20 miles an hour.

In practice drivers rather underestimate the speed they are running at, at places where they are restricted to speed of from 10 to 12 miles an hour.

The wording of the Appendix (see above) is not very clear, and may be read as not applying to a train on the up "A" route line that is not being crossed to the "B" route line, or Manchester South Junction and Altrincham line. The same applies to the wording of the Speed Board alongside the junctions as a simple "20 miles an hour" would suffice if that speed applied to all trains. The condition of the rails showed that trains had run at high speed through the facing points. Although the platelayers and signalmen say that the speed often exceeds the regulation limit, the evidence does not show that it was being much exceeded if at all on this occasion, and the driver had 3 minutes to spare in which to run the ¾ mile and bring his train to a stand at the terminus, so he had no special reason for exceeding the limit. But as mentioned above, this limit of 20 miles an hour is too high even for trains running on the up "A" route line throughout, and still more so for trains turned across the junction.

Thus in this case there was a higher speed than was justified by the conditions attending the lay out of the permanent way, and a worn flange on the leading outer wheel of the tender, binding against a worn rail, adjoining a set of facing points which led off at a sharp radius. The derailment was due to the conjunction of these circumstances.

*

Near **Wigston Station, M.R.** *On 10th May. Major J. W. Pringle reports that:—*

The 12.29 a.m. Scotch express (Carlisle to London) became divided. No one was injured.

The train consisted of a 4-4-0 engine and tender (84 tons 17 cwts.), a 4-4-0 engine and tender (90½ tons) and 12 vehicles weighing 268 tons net, fitted throughout with the automatic vacuum brake working blocks upon 80 out of the 90 wheels of the coaching vehicles. The engines were equipped with the steam brake acting upon their driving wheels and their tender wheels. The working pressure of the vacuum continuous brake was 20 inches. The equipment was not of the latest quick-acting pattern.

Wigston Station is about 4 miles south of Leicester. There are four running roads through the station. The middle pair are used for up and down passenger service, outside these there are up and down goods lines on the east and west respectively. There is a facing connection from the up main line to the up goods line south of the station. Wigston South Sidings signal-box controls the south end of Wigston Station Yard. At the north end of the station is the block post known as Wigston South Junction, and further to the north again is Wigston North Junction.

Owing to the very short interval between the signal-boxes, the two up main distant signals for Wigston South Sidings referring to the up main and up goods lines respectively have been placed under the up home signal for Wigston South Junction, and are repeated under the starting signal for the same block post. There is therefore only an interval of about 406 yds. between the outermost of these distant signals and the up home signals for Wigston South Sidings. To compensate for this unavoidable short interval an instruction is in force that the signalman at the South Junction is not allowed to lower his single up distant signal until he has satisfied himself that one of the two distant signals for the South Sidings has already been lowered. Two discs, repeating the movements of these signals, are provided in the South Junction cabin to give this information.

This slight accident might have had very serious results if the enginemen had failed to observe the signals; driver Costin was alert and acted with commendable promptitude.

Signalman York states that the express was signalled forward from Wigston South Junction to South Sidings at 5.50 a.m. with the proper number (4) of beats on the bell, after the call attention signal of one beat had been sent and acknowledged. The train was accepted from South Sidings as an "express" by the repetition of this four bells signal. At 5.52 a.m., when York received from Wigston North Junction, the "entering section" signal for the express, he was engaged in cleaning work. He waited until he heard the sound of one of the two indicating disc signals (in his box) falling, and then lowered his starting, home, and distant signals. There is one signal only in each case referring to the main line at the South Junction. These disc signals repeat the movement of the two up distant signals for Wigston South Sidings, one of which refers to the main straight road, and the other to the crossing from the up main to the up goods road. York admitted that he did not look to see which disc had fallen. If he had looked in accordance with Rule 38 of the regulations for train signalling by block telegraph he would have seen that the signals for the goods line had been lowered, and it would then have been his duty to keep all his own signals at danger.

Signalman Franks at Wigston South Sidings contradicted York's statement. He declared that the signal he received from South Junction at 5.50 a.m. consisted of one pause, four beats on the bell. This is the recognised block signal for a class "B" goods train. Apparently, from previous intimation of the running of the express, Franks did not expect it to arrive until 5.59 a.m., and accordingly he sent the acceptance signal for a class "B" goods train. He then set the facing points for the crossing junction to the up goods line, which was clear as far as the next block-post, to the signal-box in advance, and lowered all his corresponding signals. At 5.53 a.m. he received the "entering section" signal, and looking out saw the approaching train was a passenger, and not a goods train. He held up his hands as a danger signal, but the train passed his home and directing signals and came to a stand on the junction crossing. It is impossible to say which of these accounts is correct.

When the enginemen of the express caught sight of the green light displayed on the distant signal post for South Junction, 1,050 yards from the facing points leading to the goods line, they would naturally expect to find all the signals through Wigston Station yard indicating a clear run, and would be justified in making speed. Costin, who drove the leading engine, and was primarily responsible for the brake power, states that he saw the home signal for South Junction 250 yards before reaching it, *i.e.*, when he was about 778 yards from the facing-points. At the same time he noticed that the through road distant signal for South Sidings, which is carried under the above-named home signal, was at danger; and that the bracketed distant signal on the same post, which refers to the goods junction, was lowered. He at once closed his regulator and applied the continuous brake, which acted efficiently. Passing under the bridge at the north end of the station, 358 yards from the facing points, he saw that the goods line ahead of the junction was clear, and partially released the brake, in order to avoid making too sudden a stop and thereby awaking or alarming the passengers. This accounts for his over-running the directing signals, which protect the facing points, by a distance of about 50 or 60 yards. The breaking of a coupling shackle, and the distortion of the gangway between the fifth and sixth vehicles behind the engines, was done after the express had set back on to the up main line clear of the junction points. Possibly it was caused by the buffers of the four light vehicles between the engines and the heavy bogie carriages being forcibly compressed in setting back, and the subsequent over sudden release of the continuous brake. The breakage was of course immediately made known to the enginemen and guards of the train by the total loss of vacuum, and the necessary re-coupling was carried out before the train started.

It is clear that the primary cause of the mishap was a misunderstanding between the signalmen. It seems probable that the express was rightly signalled forward by York, that it was wrongly accepted as a class "B" goods by Franks, and that this error was not discovered by York as it should have been, if he had been paying full attention to his signalling duties.

As at present arranged the up distant signal for Wigston South Junction is liable to be misleading to express enginemen. If the Company desire that warning should be given at this distant signal post of the position of the signals at South Sidings referring to the goods junction, an additional semaphore arm and lamp should be provided. Interlocking will also be necessary to ensure that the distant signals can respectively only be lowered when the proper road is set. The preferable course, however, will be to retain the single distant signal at South Junction and provide interlocking so that it can only be lowered when the signals at South Sidings for the up through road have been previously lowered. One or the other of these alternatives should be carried into effect.

*

At **Dysart Station, N.B.R.** *On 8th April. Major J. W. Pringle reports that:—*

A special mineral train (engine, tender, 39 wagons and 4-wheeled van, Bowhill to Burntisland) was run into in rear, with considerable violence by a light 4-4-0 engine and tender fitted with the Westinghouse brake and weighing 75 tons 6 cwt. (80 per cent. brakes). The brake van was destroyed, and 8 waggons more or less damaged. The guard was badly injured, and a lad porter, who was crossing the line, was struck by wreckage and killed.

The block posts on each side of Dysart are Randolph Colliery signal-box to the north, 1¼ miles, and Sinclairtown 64 chains south.

For an up train from Randolph signal-box the line rises for ½ mile at 1 in 135 and 1 in 145, and after falls for a mile at 1 in 300 to 1 in 120.

Signalman Allan, at Dysart, states he accepted the special mineral train from Randolph with the "Line clear" signal at 8.7 p.m. It arrived at Dysart at 8.19 p.m., and came to a stand at the up starting signal, with the rear brake van opposite the centre of the up platform, 66 yards from the signal-box. The up distant signal, when this train passed it, probably about 8.15 p.m., was at danger. The position of the lever working the signal is vouched for by Allan, and the enginemen of the mineral train, Johnston and Robertson, certify to the red light exposed by the signal lamp. At 8.19 p.m., when he "cleared back" to Randolph for the special mineral train, the light engine was immediately offered to him, and that he thereupon accepted it with the "Section clear, but station blocked" bell signal. The "Entering section" signal for the light engine was received by him at the same time. At this moment all the up line signals at Dysart—distant, home, and starting—were at danger. In a few minutes he heard the light engine approaching, and judged from the noise it made that it was not prepared to stop at the home signal. He ran to the window, and tried to stop the engine by shouting, but it dashed past his signal-box, and the collision immediately ensued.

The Company permit the use of the "Warning Arrangement" in connection with goods trains, light engines, etc., but where passenger trains are concerned, the full "Line Clear" signal is alone allowed to be used. Between 8 and 8.30 p.m., the night was dark, with some slight mistiness, and rain falling. But there was no actual fog, and fog-signalmen were not called out during the night. None of the enginemen, or other witnesses heard, considered that the atmosphere was such as to render the services of fogmen necessary. Signalman Allan was therefore justified by the rules in accepting the light engine under the "Warning Arrangements" in this instance. The evidence of station agent Thomson and relief signalman Clark bears on this point.

Signalman Barker, stationed at Randolph, declares that the light engine was standing at his up starting signal, and had been standing there for at least three quarters of a minute, when, after receiving the "warning" acceptance, he lowered the signal for it to proceed. He argues that, in accordance with Rule 5 *(d)*, the driver having been brought to a standstill at the starting signal, should have understood, when the signal was lowered, that the line was clear only as far as the home signal at Dysart. No one else actually saw the engine standing at the starting signal. Goods guard Black saw the engine moving past the signal-box towards the signal, and states that a few minutes previously he saw the starting signal from the signal-box, at which time it was at danger. But his evidence does not do more than prove that it was possible to see the lights of the signals at a much greater distance than that estimated by the enginemen.

The statement of Tassie, who drove the light engine, conflicts with the statements made by signalmen Barker and Allan.

It is difficult at any time to judge accurately whether a vehicle, which is slowly travelling away from one in a straight line, is moving or has stopped. On a dark night the difficulty is intensified. It is quite possible that signalman Barker may have been mistaken in thinking that the engine had reached the starting signal 300 or 400 yards away, and had come to a stand before the signal was lowered. Tassie's statement, which is corroborated by fireman Boyle, that he received no warning, as indicated in Rule 5 *(d)*, that the station at Dysart was occupied may be credited.

The distant signal for Dysart had been working satisfactorily all the evening up to 8 p.m. This is certified by relief signalman Clark, who up to the time of his relief was able to see the back light of the signal, and thereby assure himself that the movement of the lever was being obeyed. About 8.15 p.m. the mineral train passed this distant signal, and driver Johnston and fireman Robertson vouch for the fact that it was then in the proper danger position. Between 8.15 p.m. and the time of the collision (8.24 p.m.) this signal could not have been lowered by lever movement, as the up starting signal was at "danger" the whole time, and the mechanical interlocking will not allow the lever for the distant signal to be pulled over until the levers of both the home or starting signals have been previously pulled over. It would be absurd to suppose that a "danger" signal properly exhibited will in the short space of about 8 minutes become a "clear" signal, unless it is wilfully tampered with. If this had been the case there would have been evidence forthcoming. In the absence of such evidence, Tassie's statement that he saw a green light displayed cannot be credited.

Tassie is responsible for this collision, in that, although he probably received no warning at Randolph that Dysart station was blocked, the outdoor signals, both distant and home, were at danger when he passed them, there was no real difficulty in seeing these signals, and he had ample brake power at his command to stop his light engine at the home signal if he had been keeping a proper look-out. He was registered as driver in Feb. 1895, and is 45 years of age. His record shows six entries since his promotion to driver. Four for careless or rough working, resulting in two instances in the derailment of his engine; one of passing a signal at danger (in 1895) and one for failing to report his train becoming divided. All the witnesses are agreed that both he and his fireman, Boyle, were perfectly sober at the time the collision occurred.

With regard to the acceptance of trains under the "warning arrangement," so long as it is possible to fulfil section *(a)* of the Rule in question, *i.e.*, to stop and verbally caution a driver that the station or junction is blocked, the arrangement affords considerable security beyond that provided by the out-door signals. On the other hand, if a train or light engine is allowed to proceed direct to the starting or advanced starting signal without any check at the home signal, and without any caution by word or flag, in accordance with section *(d)*, it appears to be quite possible for a driver to fail to remember, or to understand, that the "warning arrangement" is in use, in which case there is no security beyond that afforded by the outdoor semaphore signals. The advisability of the use of section *(d)* of the "warning arrangement," where there are steep falling gradients to the home signal, as at Dysart, is therefore open to question.

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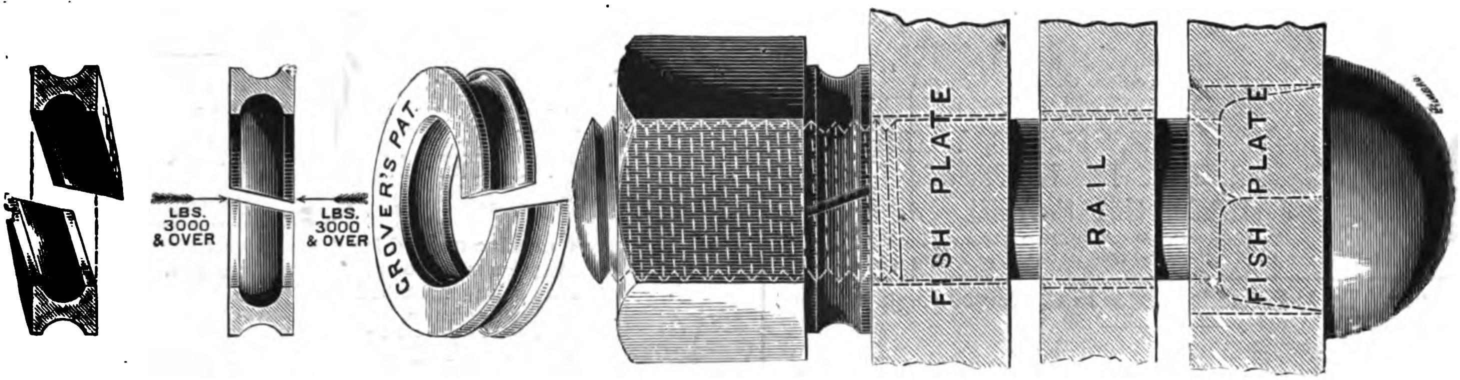

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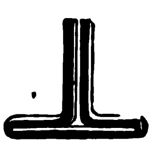

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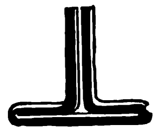

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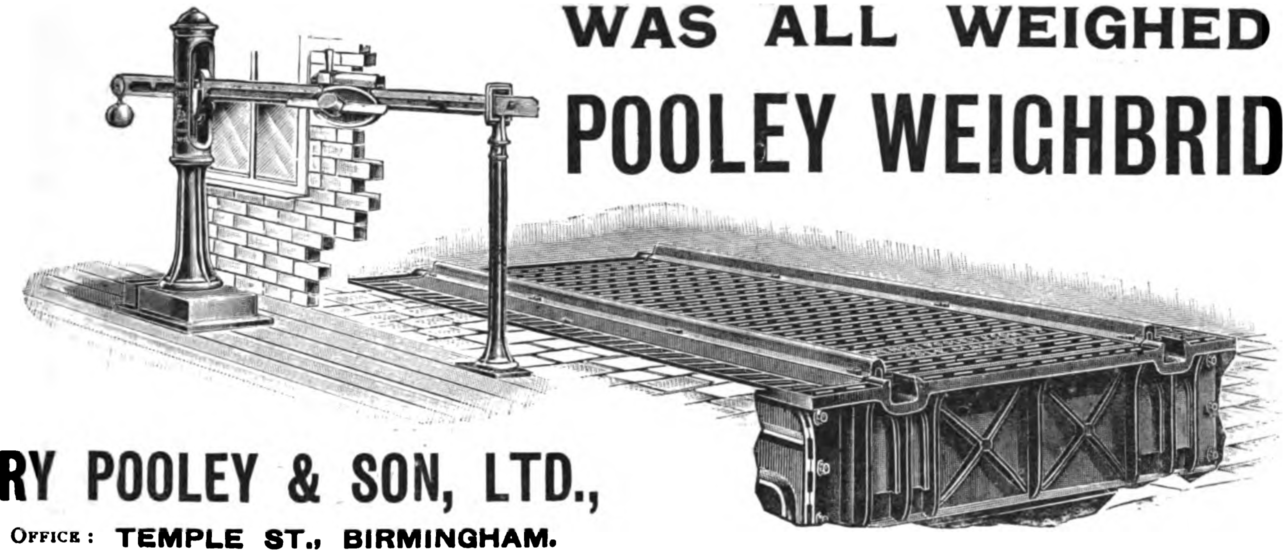

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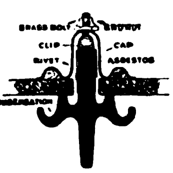

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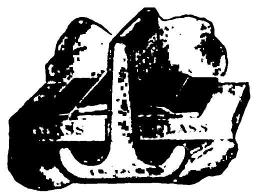

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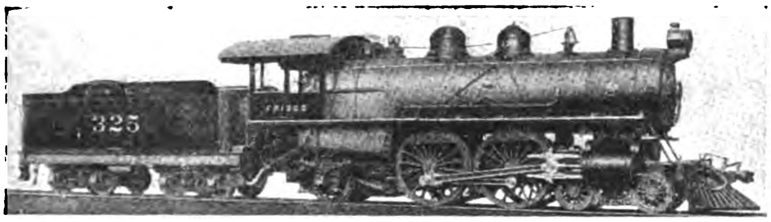

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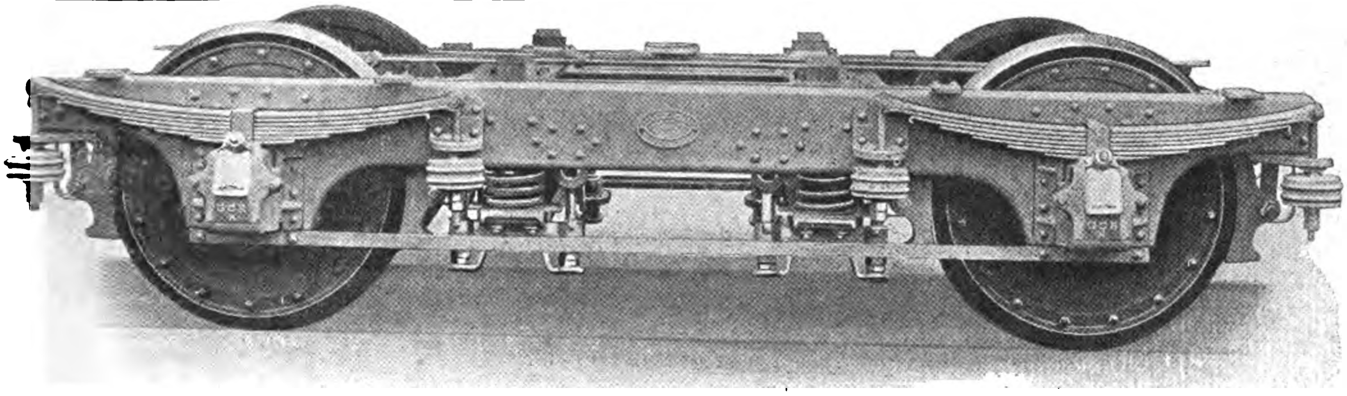

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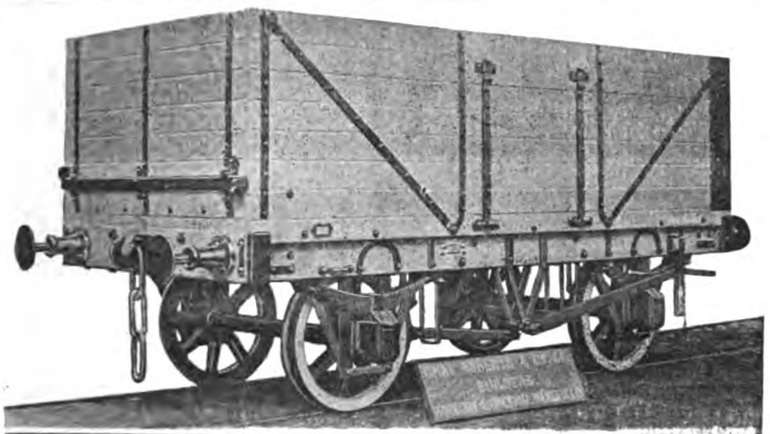

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